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Simulation Based Acquisition — Some Thoughts on Things Not to Forget

Walter W. Hollis, FS
Anne M. Patenaude

Simulation Based Acquisition is a term used in DoD and the Defense Industry recently to convey the idea of actively incorporating simulation technology into acquisition processes, extending that integration beyond the traditional stovepipes within the acquisition community, and further extending to the requirements, training and logistics communities. The concept conveys that the sharing of the developed models and simulations will be made across acquisition programs and across the Services in some cases. The concept also implicitly demands a robust configuration control process to ensure the simulation at all times represents the intended product. The DoD vision, as stated by Dr. **Jacques Gansler**, Under Secretary of Defense for Acquisition and Technology, and Dr. **Patricia Sanders**, Director, Test, Systems Engineering and Evaluation for OSD, is that Simulation Based Acquisition will generate savings in cost and schedule, as well as reducing risk.

These thoughts become more important in the environment of decreased funding and manpower when we are making efforts to get advanced weapons to the field sooner.

The challenge is to get stakeholders to commit to this process by developing robust models and simulations, <u>and</u> using them in a collaborative fashion. The step to be taken, beyond what a weapon system program using modeling and simulation in acquisition does now, is to develop simulation technologies for more than one function (e.g. training or testing) or for multiple acquisition programs.

Walter W. Hollis, FS
Deputy Under Secretary of the Army
(Operations Research)

The intent of Simulation Based Acquisition for the Army is to use simulation technology to:

1. Explore the trade space when identifying performance requirements;
2. Assess design alternatives for performance, logistics, manufacturability, operability, maintainability, cost, etc.; and,
3. Provide soldiers with training opportunities without leaving the motor pool parking lot.

Cradle to Grave. The question becomes how to implement this idea of breaking out of the traditional stovepipes in which we've done business. The models developed during concept development by the Army's Training and Doctrine Command can be incorporated into work done by the requirements technical community. Virtual Prototypes can be used to do some of the groundwork that was previously done by building physical prototypes, for example; design level for stability, etc. But that is not enough, there are still tests that need to be run at some point. What the simulations and prototypes can do is allow the Operational Tester to focus on what really needs to be tested in the field. The Army Acquisition Community captures most of this in what they call 'SMART,' Simulation and Modeling for Acquisition, Requirements and Training. They're on the right path but we still need to work the logistics tail into what we're doing to achieve Simulation Based Acquisition.

Simulation technology becomes an enabler to work the interfaces between requirements and acquisition, as well as acquisition, training and logistics. In a very real sense, the acquisition community is somewhat held hostage by the requirements community when a 'waterfall' approach is used, just as the training community is held hostage to the decisions made by the acquisition community. Using an environment of linked simulations we can accomplish more parallel efforts instead of the handoffs of the serial approach.

Challenges. One of the challenges to increased use of simulation technology is who maintains the models and keeps them

(See **ACQUISITION,** *p. 28)*

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THE ISSUE TODAY

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Developing the Junior Analyst for 1998/99 — Halftime Report

Dennis Baer
MORS President

By the time you read this article, the current MORS team will be almost halfway through their term of office. I will briefly talk about accomplishments to date and discuss our strategy for the second half of the ballgame. A balance between the meeting operations and the professional affairs side of the house has been maintained. A quick review of the first half is provided at the beginning of each section, with the necessary focus for the second half following.

Meeting Ops

With Dr. **Roy Rice** (Teledyne Brown Engineering) at the overall helm of Meeting Ops, we have successfully completed two special meetings. Dr. **Cy Staniec** (Logicon), our Special Meetings Chair, has provided the leadership at the detail level for both past and present meetings this year. The first meeting, held in August, helped focus the Simulation Technology ten years ahead. Dr. **Stu Starr** did a superb job of leading this three day effort and a summary of the meeting will be provided in a future issue? MORS very much appreciates the level of effort provided by RADM **Nutwell** in the C4ISR Workshop held at the Army War College. We also appreciate the efforts of CAPT **Jay Kistler** (N6M), Deputy Chair; Dr. **Russ Richards** (Mitre), Technical Chair; and both **Pat Peterson** and **Barry Dysart** (SAIC) for their efforts in organizing this great workshop. Details of this workshop will be provided in the next issue of *PHALANX*. Ms. **Anne Patenaude** (SAIC) has done a great job to date with her "Brown Bag" lunches guiding the rest of her 67th staff in preparing for the 67th MORSS this summer at West Point. A word to the wise for everyone, hotels are at a premium, so make reservations early. CDR **Kirk Michealson**, (OSD PA&E), has done a super job in organizing the Working/Composite Groups this year. His monthly newsletters and "enormous" flow of e-mail has increased the communications between all 33 working groups this year. I firmly believe the Working Groups/Composite Groups (WG/CG) are basically the heart and soul of our Society, and they should be used year around, not only at our annual symposium.

Second Half Strategy includes the successful completion of both the SIMVAL 99 at JHU/APL and the Joint Experimentation Workshops in the Norfolk, VA area. The WG/CG chairs and the 67th Staff will continue to build a strong program for the West Point summer event. We will also start looking at potential Special Meetings for next fall.

> ## Upcoming MORS Meetings
>
> **SIMVAL 99**
> 26, 27, 28 January 1999
> The Johns Hopkins University/APL
> Laurel MD
>
> **Joint Experimentation Workshop**
> 8, 9, 10, 11 March 1999
>
> **67th MORS Symposium**
> 22, 23, 24 June 1999
> US Military Academy
> West Point, NY

Professional Affairs

CAPT **Lee Dick's** (N75) positive leadership has helped keep the Professional side of our house in good order. Publications of the Society are being brought on-track by Mr. **Brian Engler** (Systems Planning & Analysis). The backlog of Special Meeting reports will almost be complete by the time this article is published. These reports are a true test of the Society's leadership and ability of a volunteer society to provide a product away from the MORS work environment. I would appreciate everyone's effort in completing their part of the report before they leave any workshop. MAJ **Willie McFadden** (PhD student, Old Dominion University) has already began making plans for the Spring Education Colloquium, to be held in the D.C. area. Stay tuned on the MORS web site for further information. Mr. **Ted Smyth** (JHU/APL) is overseeing a Operations Research oral history project by Mr. **Gene Visco**. Maj **Mark Gallagher** has begun to coordinate the reading of both the Rist and Barchi Prize papers. The winners will be announced during one of the Special Sessions at the 67th MORSS.

Second half focus will be on the Spring Education Colloquium to support the MORS theme of the Junior analyst.

The great efforts of finance and management led by Ms. **Sue Iwanski** and Secretary of the Society, Dr. **Tom Allen** will be discussed in the next issue.

Use of the Theme – "Developing the Junior Analyst"

We hope everyone gets on board with this theme. The MORS Executive Council has taken the lead by each adopting a junior analyst to mentor during the year. Time is spent weekly by each senior analyst providing analytical knowledge and methodologies not normally obtained in any textbook. Other committees have ensured this theme is presented. The WG/CGs have promoted the Junior Analyst as one of the WG co-chairs during the 67th MORSS. We are planning on having two Junior/Senior Analysts sessions this year.

I made a delightful trip to the United States Air Force Academy in October as a guest speaker for the Junior and Senior Seminars. I discussed the basics of analysis, what's going on in D.C. area analytical scene and gave a quick introduction to MORS. I also spent time with two cadets discussing their summer research projects. It is certainly great knowing the Operation Research community has such a bright future with the ladies and gentlemen graduating soon.

(See **MORS PRESIDENT,** *p. 32)*

MAS — The Next Phase

Tom Gulledge
MAS President

By the time this column is published, I will no longer be the President of MAS. The previous two years have been productive, and I am pleased to leave a financially viable and growing organization to my successor, Dr. **Bruce Fowler** [FOWLER-BW@redstone.army.mil]. Bruce and I are in close contact (almost daily), and the transition is already underway. Bruce has some great ideas and a good vision for the future of MAS — your Society is in good hands.

The transition of officers will take place at the Seattle INFORMS meeting, and Bruce will report the results of the election in his first *PHALANX* column. We are planning a large military meeting for Seattle, as well as a management off-site to plan for the future of MAS. A number of change initiatives are underway in INFORMS, including a move to a single annual national meeting. When this transition is completed, it is almost certain that our MAS Council will propose an annual MAS meeting. In fact, the second MAS National Conference is already planned for next fall in the southwest. The details will follow later, but here is some advance information.

The US Army Air Defense Center and TRAC White Sands will co-host the Second International Military Applications Society Conference during the last week of September 1999. The conference chair will be **Philipp Djang** [djang@trac.wsmr.army.mil]. Thanks to the superior facilities and support accorded by the US Army Air Defense Center, you can expect a first class conference. However, this major event of the society cannot take place without your support and personal efforts. We would like to encourage volunteers for track chairs. Some of the tracks we propose are:

- Theater Missile Defense
- Space Operations
- Electronic Warfare
- Joint Campaign Analysis
- Joint Mobility Analysis
- Naval Operations Analysis
- Logistics, Reliability and Maintainability
- Modeling Low Intensity Conflict and Operation Other Than War
- Advanced Warfighting Experimentation
- Future Impacts of Budgetary Reductions on Force Design
- Manpower Modeling
- Cost and Resource Analysis
- Readiness, Personnel, Training
- Distributed Simulation and Distributed Testing
- Military Decision Analysis
- Advanced Operations Research Methods
- C4IR and Intelligence Operational Analysis

Please contact Philipp for conference information, or to volunteer to participate as a track or session chair. A call for papers will be issued shortly.

The second featured item of this column is our continued focus on the MOR programs in our service academies. If there is one area that has become closely associated with my presidency, it has been the focus on our MOR educational institutions. In the last *PHALANX* issue, I reported on the award that was presented at the US Military Academy. In this issue, I focus on the US Air Force Academy.

Thomas Gulledge presenting the MAS Award to Cadet Scott D. McKeever

This year the Air Force Academy graduated 69 cadets in OR, the largest class to date. The recipient of the MAS award for the best cadet in OR was Cadet **Scott D. McKeever**. Cadet McKeever received a Draper Fellowship in Operations Research and will continue his studies at MIT this fall. Following his Master's Degree, he will attend the premier undergraduate pilot program, Euro-NATO, at Sheppard AFB, Texas.

Cadet McKeever completed his OR program by serving as cadet team leader of a call center simulation project for USAA, Inc. The USAA Rocky Mountain Region is expanding their operations by 2 hours daily. The Regional Vice President personally attended the cadets' final briefing and was impressed with their analysis. The model is being used by USAA analysts to simulate the effects of various staffing profiles of the extended hours of operation. Congratulations to Cadet McKeever for his achievements and we wish him the best as he continues his academic career at MIT.

As usual, feel free to contact me by Internet [gulledge@gmu.edu]. The MAS Council continually monitors the MAS Listserver, and you can always contact the membership or us by this means. If you are not already a member of the list, you can subscribe by sending the following message to majordomo@mat.gsia.cmu.edu:

subscribe mas Your Name,
Title < yourname@domain.org>

If you have problems, send a note to Philipp Djang. He doubles as the moderator of the list. I will use the listserver to provide information of interest to the Military Operations Research community as it is passed to me. I encourage you to do the same.

Finally, I thank you for all of your support during the last two years. Military Operations Research is alive and well, and through your continued support of organizations like MAS, we will continue to grow our profession.

Supporting the Decision Makers

Dr. **Tom Allen**
IDA

Customarily, officers of MORS are given one opportunity each year to discuss new developments in their area, so that readers can keep up with the many advances going on throughout the Society. Fortunately for me, two committees, with superb track records and very able leadership, support the Secretary: Membership under **Dean Hartley**, and Electronic Media, led by **Glen Johnson**. Stable membership size despite major reductions in defense, and effective communication about MORS and its events resulting from a constantly improving web site, underline the contributions of these groups. Suffice it to say that both committees welcome suggestions and volunteer help to maintain this record of success.

Instead of discussing secretarial matters, I'd like to address another area of importance to MORS, which is the relationship of analysts to the decision makers and commanders they support. Thirty years of experience in the business listening to comments like those provided by BG **John Scales** in his article in the last edition of *PHALANX* have convinced me that our community has not been ineffective in convincing defense leaders about the full value of our profession.[1]

There is no question that Secretary of Defense **MacNamara** brought a new focus of cost effectiveness to military operations research, with new systems undergoing detailed scrutiny and having to prove their worth by demonstrating, at least on paper, improved performance for less cost than alternatives. This fueled the development of a vast array of new models, methodologies and approaches to enable manufacturers, acquisition agents, commanders and high-level decision makers to compare the effectiveness and cost of various proposed systems in battlefield conditions. Analysts have responded to this environment by reviewing various options of differing force size and equipment in order to help decision makers determine which of the alternatives meets the stated requirements at least cost.

While this is an important aspect of analysis, it is far from being the community's only contribution. We go astray whenever we allow our focus to be reduced to just the engineering values and cost factors associated with a comparison of new systems. The problem is that even when we know the issues are more complex, we often assume away critical variables (especially human-related factors) because we and the commanders we serve do not have quantifiable measures in hand to describe the effect of these variables on the battlefield.

The truth is, military operations research has much to offer in addressing these complex variables. We need to work with operational experts to both define them and better understand their effects. We've solved most of the easy problems; now we need to understand the impact of human-related variables such as tactical execution, readiness, morale and training on battlefield outcome and then include the appropriate measures in our analyses.

Studying these factors is not just the purview of leadership and military science; operations researchers are obligated to bring our scientific approaches to bear and assist in this study. It is a fact that the best commanders look for ways to understand and apply these human-related factors to their advantage on the battlefield. The fact that such variables are hard to define and measure does not mean they should be ignored. In fact, as **Napoleon** and General Scales point out, the impact of these variables can far exceed any marginal improvement to firepower associated with fielding new systems or force structures.

This does not mean that the OR community should stop looking at efficiency and effectiveness. Far from it, with the continuing pressure on military budgets, the services and the Department of Defense must find least cost solutions to an ever-increasing number of modernization and force structure challenges. What it does mean is that the OR community must also expand in other dimensions to meet the full demands of the customers they serve.

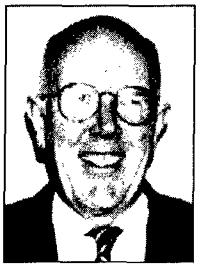
As in our other efforts, we must create the databases, develop the theories and then shape the tools, methods and approaches necessary to help commanders deal with the full range of operational issues. Analysts need to provide insight into the effects of training as well as to expand the community's understanding of strategic impacts and maneuver-based warfare in order to help shape battlefield options to achieve victory more quickly and decisively than traditional attrition-based approaches.

General Scales is right when he points out, "...research analysts are often not at the right hand of the decision maker..."[2] The reason is not because the analytic community is incapable of assisting commanders, but rather because we analysts have not shown the commanders that we can bring relevant thought to bear on their toughest problems.

No commander worth his or her salt wants to be dictated to by an opaque computer model that everyone knows is missing relevant information; on the other hand, every good commander I've ever served is eager to listen to smart, objective insights to help improve their understanding of a problem. The more analysts provide such relevant insight — improving both our own and the decision makers grasp of an issue and ability to make credible, defendable choices — the more likely we will find ourselves invited into the decision-mak-

(See **VEEPS PEEP,** *p. 29)*

Information Superiority and Game Theory: The Value of Information in Four Games



Dr. **Jerome Bracken**
RAND

Dr. **Richard Darilek**
RAND

This article is based on work performed in the RAND Arroyo Center for the US Army.

OVERVIEW

Three overarching concepts tend to frame predictions about the future in which US military forces are expected to operate. The first of these is the notion that an Information Age is just beginning to unfold and that it will largely define the first half of the 21-century. Like the Industrial Revolution that held sway throughout the latter half of the 19th century, the new era promises, among other things, to transform the nature of future military operations — so much so that it is predicted to result in a Revolution in Military Affairs (RMA).

Such a revolution is the second major concept currently framing predictions about future forces. For an RMA to occur, the role of information — its technologies and their organization — is generally considered to be critical. In particular, through the development of Information-Age technologies, the RMA is expected to produce Information Superiority (the third overarching concept), which future US forces are expected to enjoy over their opponents. A "vision" of information superiority, in fact, pervades *Joint Vision 2010*, where such superiority is defined as the "capability to collect, process, and disseminate an uninterrupted flow of information while exploiting or denying an adversary's ability to do the same."[1]

We focus here on this notion of information superiority. We want to explore its conceptual dimensions somewhat further. In particular, we would like to understand how much information superiority might be required — how much is enough, if you will — for US military forces to be able to enjoy truly revolutionary advantages over their opponents in an Information-Age future.

Information Superiority and Game Theory: Probabilities of Victory

Side 2 \ Side 1	a	b	c
a	12	79	4
b	34	5	86
c	91	22	52

# of Strategies per side	Game 1	Game 2	Game 3	Game 4
3 X 3	50.0	62.5	57.5	75.2
5 X 5	50.2	60.8	65.4	83.0
10 X 10	48.9	58.9	75.4	91.2

Game 1: Both sides have common knowledge of values associated with their strategies

Game 2: Side 1 knows values associated with strategies of both sides. Side 2 does not.

Game 3: Both sides have common knowledge of values associated with strategies. Side 1 knows Side 2's choice of strategy.

Game 4: Side 1 knows values associated with strategies of both sides. Side 2 does not. Side 1 knows Side 2's choice of strategy.

Arroyo Center **RAND**

To address the question of how much information might be required for US forces to achieve superiority, we have drawn upon game theory as a methodology that looks to be directly relevant to such questions. In the applications of game theory presented below, therefore, we have compared military operations to a zero-sum, two-sided game. For these games, we posited that each side has 3, 5, or 10 choices or "strategies" available for achieving victory.

For each game, we vary the kinds of information available to the two sides. The 3x3, 5x5, and 10x10 rows in the chart above, therefore, could be taken to represent the probabilities of victory or "payoffs" for Side 1 (the US). In fact, these payoffs represent the calculated averages of 1000 trials of 3x3, 5x5, and 10x10 games composed of random numbers uniformly distributed between 0 and 100. A detailed description of the analytic process involved in developing this chart is included below.

In Game 1, both sides are assumed to have common knowledge of the values associated with their strategies — i.e., both sides know what the random numbers are that appear in all rows and columns of the 3x3, 5x5, and 10x10 matrices created by their opposing strategies. In other words, both sides have the same information and neither benefits from information superiority. Since the underlying payoffs are random and distributed uniformly between 0 and 100, the expected payoff is 50. Any other result of the 1000 trials would indicate that our computer program was incorrect.

In Game 2, Side 1 (the US) knows the values associated with the strategies of both sides — i.e., it has information superiority — but Side 2 does not; it has bad information. This situation may be similar to the one that US Army expects to face during the first decades of the 21st century, when the US will be dealing with potential enemies who seem likely to lack the Army's highly digitized and internet-

ted units (i.e., the Army XXI forces currently planned to be in the field around 2010).

In Game 3, both sides have common knowledge of the values associated with their strategies, but Side 1 (the US) knows Side 2's choice of strategy. In other words, Side 1 possesses perfect intelligence and, as a result, another kind or higher level of information superiority, even though Side 2's basic information in this case (as opposed to Game 2) is not bad. This situation reminds us of a capability proposed for the Army After Next (AAN), which the Army hopes the RMA will have enabled it to develop by about 2020 or 2025; the AAN aims to have such perfect intelligence.

In Game 4, Side 1 (the US) knows the values associated with the strategies of both sides, Side 2 does not know, and Side 1 knows Side 2's choice of strategy. In this instance, Side 1 has both perfect information and perfect intelligence; it may even have established this position by actively ensuring (through offensive information operations, for example) that Side 2 has bad information. Thus, Side 1 enjoys not only information superiority but also what might be called information dominance. This recalls one of the key objectives not only of the AAN but also of the Army as a whole, which proclaimed in *Army Vision 2010* that "Gaining Information Dominance .... is fundamental to ... each of the operational concepts in *Joint Vision 2010*."[2]

Of particular interest is Game 4. With 10 strategies on both sides, Side 1's probability of victory rises to 91.5, an outcome due entirely to Side 1's absolute information superiority and dominance in this case. What the outcome suggests is that control of information is the single most decisive key to victory for the US military in the future. Correspondingly, lack of information superiority in the future could prove to be devastating to the side that finds itself in the inferior position.

Also implicit in these games is the notion that information superiority and dominance result from dynamic interactions between the two sides. These can change over time — e.g., during the course of a conflict. Hence, we should guard against thinking of information superiority or dominance as static conditions that, once obtained, endure for one side or the other indefinitely. Prudence suggests viewing them as military objectives to be achieved or restored, perhaps only temporarily.

These games, of course, represent relatively simple, abstract calculations. In lieu of harder data on 21st century forces, which it is still too soon to expect, such games simply help demonstrate the theoretical or potential contribution of information superiority and information dominance to victory. Although they are instructive, these abstract calculations and theoretical models cannot yet serve as a reliable basis for policy or programming choices. Prudence and common sense suggest that a series of carefully structured and controlled field experiments will be needed to test the validity of any theoretical model's results.

ANALYSIS

This process shows, for a very simple and easy-to-understand situation, how the outcome of a zero-sum game changes as the information of the two sides changes.

In addition to four different basic assumptions about the information available to both sides we consider three cases of dimensionality with respect to the number of strategies or choices available to both sides. We allow each side three, five, or ten choices. The effects of information differ depending on this characteristic of the game. (This feature of the game has some intuitive relationship with warfare because a commander, or combatant, can only logically process a certain amount of information in a stressful situation, which may lie in such low-dimensional regions as these.)

We also perform a sensitivity analysis of the effect of one side's using a non-optimal decision rule rather than an optimal strategy. This provides insight into the differences between decision processes based on decision rules versus decision processes based on game-theoretic solutions.

Description of Two-Sided Game and its Solution

Side 1 has choices $i = 1,...,m$ and Side 2 has choices $j = 1,...,n$. For each choice there is a payoff a_{ij}. Side 1 receives a_{ij} and Side 2 loses a_{ij}. Side 1 wishes to maximize the payoff and Side 2 wishes to minimize the payoff.

The choice of the optimal action i* of Side 1 is made by computing, for each choice of Side 2, the minimum that Side 1 can gain, or:

$$a_i^{min} = \underset{j}{\text{minimum}}\ a_{ij},$$

and then choosing the i* which maximizes the minimum that Side 1 can gain, or:

$$i^* = i \text{ corresponding with } \underset{i}{\text{maximum}}\ a_i^{min}.$$

This is the maxmin strategy of Side 1.

Similarly, the choice of the optimal action j* of Side 2 is made by computing, for each choice of Side 1, the maximum which Side 2 can lose, or:

$$a_j^{max} = \underset{i}{\text{maximum}}\ a_{ij},$$

and then choosing the j* which minimizes the maximum that side 2 can lose, or:

$$j^* = j \text{ corresponding with } \underset{j}{\text{minimum}}\ a_j^{max}.$$

This is the minmax strategy of Side 2.

For the Side 1 choice i* and Side 2 choice j* the payoff of the game is:

$$\text{Payoff of Game} = a_{i^*j^*}.$$

This payoff is guaranteed to be equal to or greater than the maxmin payoff corresponding to i* and equal to or less than the minmax payoff corresponding to j*. Side 1 receives at least his maxmin payoff and Side 2 loses at most his minmax payoff.

The specific implementation of the game explored in this paper is to generate using random numbers payoffs from 0 to 100. The Side 1 maxmin strategy and Side 2 minmax strategy are found and the payoff associated with this strategy pair is saved. The process is repeated 1000 times and the average payoff computed.

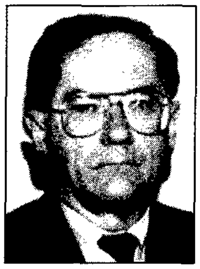
Three cases are studied, as follows:

3X3 game with 9 payoffs
5X5 game with 25 payoffs
10X10 game with 100 payoffs.

(See **GAMES,** *p. 33)*

ADS for Analysis — Much Agreement, Important Differences

Bart Bennett
RAND



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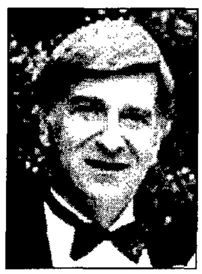

Dr. **Bob Kerchner**
RAND

Introduction

This note is our rejoinder to **Gary Coe**'s comments in "ADS for Analysis — A Different View"[1] on our "ADS for Analysis: The Reality and the Hype!"[2] article. In particular, we want to clarify a couple of important points that were misinterpreted by Mr. Coe. We, in fact, concur with many of his positions. There are, however, some important differences. These arise from considerations on how models and simulations, including Advanced Distributed Simulation (ADS), should be used within an analysis to best inform the decision making process. Furthermore, we strongly disagree with Mr. Coe on the magnitude of the analytic challenges associated with reliable ADS-based experiments and their potential effects on an analysis. As a consequence, we emphasize the need to carefully heed "historical" design of experiment principles when conducting experiments using ADS.

We believe that ADS technologies will be an increasingly important analytic tool and our intent is to help ensure that their analytic potential is realized. We want to avoid excessive hype of "ADS for analysis" followed by dashed expectations — and reduced investment.

Clarifying a Few Points

Since ADS is becoming an important analysis tool it is valuable to understand where analysts agree and disagree. Towards that end we begin by reviewing some of Coe's mischaracterizations of our views on important aspects of analysis and ADS. These include subtle wording differences that change our intended meaning, and inaccurately attributing positions to us on topics we did not address in our original *PHALANX* article. A more extensive treatment of "ADS for Analysis" can be found in "*A Guide to Analysis Using Advanced Distributed Simulation*"[3] and "*Understanding the Air Force's Capability to Effectively Apply Advanced Distributed Simulation for Analysis*"[4]. Now, let's clarify some important "ADS for Analysis" issues.

***Coe:** "Although the RAND idea of using human-in-the-loop experiments to calibrate constructive simulations may have merit, it is believed that this view is too narrow as a scheme for improved use of ADS in analysis."*

We agree, which is part of the reason we were careful never to write "calibrate" in "*ADS for Analysis*: The *Reality and the Hype!*". We write that one of the important analytic uses is to use "ADS runs [to] inform human performance factors and other factors in constructive models." The other factors (perhaps how battles evolve or operational concepts associated with new systems or scenarios) may be more important; this will be highly dependent on specific study objectives. We also believe that the ADS runs can provide valuable information in and of themselves. We state that the few ADS runs are "the use most visible to the consumers of the analysis and correspond to high-value ADS runs for scenarios of interest." There are other good uses for ADS as well, many yet to be discovered.

***Coe:** "The RAND article assumes that constructive models and ADS have uniquely different attributes that need to be normalized in some way."*

We make no such assumption. Constructive models are an important element *within* ADS. The ADS vision, as articulated in "*ADS for Analysis*: The *Reality and the Hype!*", is that one can "realistically simulate...with joint, live, virtual and constructive elements participating." In many ADS applications constructive models simulate the majority of entities. Our point is that models "with different algorithms, approaches, purposes and different levels of resolution" will almost surely, when interacting on the synthetic battlefield, generate biased outcomes. That is, some models, systems, players and entities will have unintended systematic advantages over other simulation elements. This is sometimes called an "unfair fight." These inevitable biases, if not understood and accounted for, may lead to erroneous insights. While potential sources of bias are a concern with many simulations, the nature of ADS greatly exacerbates the problem.

***Coe:** "Rather than think about ADS in terms of special properties such as distributed simulation, it is more important to understand how each of these technologies...may contribute to analysis."*

We emphasize distributed simulation because it is the primary "new" development. One of then - Lt Col **Bob Sheldon**'s working group's primary findings at the 1996 MORS ADS for Analysis Workshop was that "ADS is not a new methodology for analysis — all the components, including human-in-the-loop, have been available to analysts for years. Rather, it is glue that allows analysts to tie together formerly stand-alone analytic tools into a more powerful mechanism for modeling complex problems." Simulation elements like "Synthetic Forces" and "Synthetic Environments" have existed in ever more detailed versions for decades.

__Coe:__ "The RAND paper cites the value of visualization in communicating analy-

sis results to the decision maker. Why is it not equally important to analyze processes visually...?"

We don't disagree, but simply had insufficient space in our earlier *PHALANX* article to enumerate all the values of all ADS attributes. The visualization that is inherent (though not unique) in ADS is one of its primary benefits and should be exploited in many ways. In "A Guide to Analysis Using Advanced Distributed Simulation"[3] we write "Visualization tools [are part of the] summary and review process, although their use, of course, transcends just this application. The authors have been involved in constructive simulation study efforts...where for all intents and purposes the *only* quick review tool we really needed was a visual playback of the scenarios that had just been run."

Coe: *"It is believed that beyond traditional analysis, ADS benefits a larger domain than only the human dimension — specifically the information domain."*

Our emphasis on ADS's facilitating the incorporation of real warfighters in simulations should not be construed to imply that only studies "on the human dimension" benefit from ADS. Rather, any domain where human performance is critical may potentially benefit. This is a vast area; for example, we noted in our earlier *PHALANX* paper that it has been stated by Marshall and Garrett[5] that "ADS should be particularly useful in modeling C4ISR."

It turns out that we have more in agreement with Mr. Coe than his article suggests. Most of the examples he cites as ADS advantages are simply specific examples (e.g., STOW 97) of some of the more general analytic ADS advantages we listed. However, the points of disagreement are more interesting and we will now address a few important ones.

On Analysis, New Paradigsm, Experimental Design Principles, and Decision Making

Effective use of simulation experiments in an analysis depends on the nature and context of the analysis. For this note we take the perspective that analysis is the process of learning about complex systems and their interactions to improve decision making. Analyses are usually commissioned because someone needs to make a decision among some group of choices — and subsequently to help justify the option selected. Here, "decision" is used very broadly; ranging from specific materiel acquisition decisions to determining what general operational concepts should be explored further. A successful analysis is one that produces a compelling argument for making the best choice from the available options.

Military analysis, as well as analysis in other public policy areas, is not an exact science because of the vast number of unknowns explicitly or implicitly cast as assumptions and assertions.

The critical question is: What role can/should simulation experiments play in synthesizing an argument for or against a potential decision? Military analysis, as well as analysis in other public policy areas, is not an exact science because of the vast number of unknowns explicitly or implicitly cast as assumptions and assertions. Among other uses, simulation experiments can provide information on these unknowns. Simulation experiments are usually the most informative if they are designed to assess specific load-bearing hypotheses gleaned from unknowns in a tentative argument constructed to (potentially) make a decision.

The history of human discovery is rife with examples of poor or erroneous conclusions drawn from improper use of experimental results. Our primary areas of disagreement with Mr. Coe centers on how one should reason given the presumed "realism" of combat simulations and the resultant importance of traditional design of experiment principles as a tool to efficiently learn from simulation experiments. ADS is certainly a new capability for performing mixed live and computational experiments. Although new methods may be developed, we believe that full advantage must be taken of experimental design techniques to minimize errors in the decision making process and to strengthen the arguments that utilize ADS. We worry that if analysts put too much faith in "vicarious" simulation experiments and do not support the analysis with "traditional methods" the insights gleaned by visualizing the processes within a few high-resolution STOW simulations may be persuasive illusions that foster poor decision making.

Mr. Coe notes that analysts help decision makers by providing "insight" and "information," rather than the "right answer." In general, we agree. We may disagree, however, on how this is done. In his article, while describing STOW 97, Mr. Coe uses the words "realistic" or "good fidelity" more than half a dozen times. While many of the subcomponents may be good models or even the actual equipment, due to a dearth of empirical data, a belief that any simulation of potential future campaigns is "realistic" relies more on faith than demonstrable evidence.[6] There are countless potentially causal unknowns and uncertainties (e.g., a threat's tactics and its will to fight, systems' effectiveness and reliabilities, environmental factors, other stochastic realizations, etc.), in addition to inevitable model biases, that necessarily were not addressed in STOW 97.

STOW 97-type simulations facilitate looking at a few high-resolution (not necessarily high-fidelity) cases — though subevents and processes may occur many times. But, most combat simulations, such as STOW 97, are <u>not</u> validated in the sense that their outcomes can credibly be considered predictions of potential real-world outcomes with known accuracy. Thus, bad decisions can result from arguments that at their core assume the validity of these unvalidated simulations. Dewar et al. gives several approaches to credible reasoning with nonpredictive simulations.[7] Most

(See **ADS,** *p. 10)*

ADS
(continued from p. 9)

of these approaches require running a large number of cases (i.e., varying lots of uncertain things) with the veracity of any individual case being of lesser importance.

Concerning new analytic paradigms, Mr. Coe writes that there might be "new approaches to data analysis such as in greater dependence on visualization vice statistical analysis." We are big fans of visualization. However, we believe that more rather than less statistical analysis is needed to help us decipher whether apparent patterns are real or can be explained by the random variation inherent in battle (or data mining). As Efron and Tibshirani write, "Left to our own devices we are not very good at picking out patterns from a sea of noisy data.[8] To put it another way we are all too good at picking out non-existent patterns that happen to suit our purposes."

Finally, as to needing "to develop new (analytic) processes." We agree, and presented one such possibility in *"ADS for Analysis: The Reality and the Hype!"*; however, we argue strongly that the new processes must be mindful of why some of the "traditional" approaches were developed. Over time the scientific community has adopted several experimental design principles. Some important ones are called randomization, replication, blinding, blocking, control, sensitivity analysis and peer review. These were learned by carefully examining why some important experiments produced erroneous conclusions. The cause of error in an experimental design can be very subtle, such as the Hawthorne Effect; see **Roethlisberger**.[9]

Freedman et al. and **Schulz** et al. have excellent discussions on the consequences of violating design of experiment principles.[10, 11] They review several examples that relate the conclusions of a large number of similar studies to how well they were designed. They reveal a strong inverse relationship between the studies' conclusions on the efficacy of a variety of (medical) procedures and the quality of the designs (as measured by some of the above principles). Schulz et al. writes: "This study provides *empirical* evidence that inadequate methodological approaches...are associated with bias." It can be hazardous to assume that the defense community is somehow immune to these experimental challenges. An illuminating discussion on how erroneous insights were obtained on anti-tank tactics and system effectiveness (and the subtle biases that caused the errors) in the 1941 Louisiana Maneuvers is contained in **Gabel**.[12] *It is simply an established fact that intelligent well-intentioned people with area expertise can make bad decisions (in terms of lost money or lives) when their experiments violate the above principles.* Thus, the need to support new analytical capabilities (such as STOW experiments) with traditional experimental principles and methods.

We applaud Mr. Coe for his vigorous support of ADS technologies, and for articulating what was achieved in STOW 97. We see many of the potential analytic benefits he does and hope they are realized.

Final Thoughts

We applaud Mr. Coe for his vigorous support of ADS technologies, and for articulating what was achieved in STOW 97. We see many of the potential analytic benefits he does and hope they are realized. Indeed, we believe that ADS technologies are *critical* in our efforts to understand the evolving vision of future warfare as articulated in Joint Vision 2010.[13] Towards that objective we trust that this rejoinder helps illuminate those areas in which we disagree about how to best achieve ADS's analytic potential. As with any radically new capability advances will not be made without a healthy debate. We believe that the debate is most productive if we carefully analyze the foundations of the differences.

Acknowledgement

The authors thank Professor Jim Hodges, University of Minnesota, for his assistance in the content and presentation of this material.

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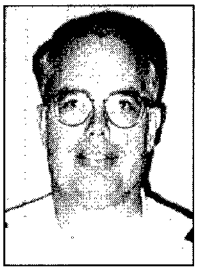
In Pursuit of M&S Standards



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Introduction

In the book *Alice in Wonderland*, by **Lewis Carroll**, the following conversation takes place between Alice and the Cheshire Cat:

"Would you tell me, please, which way I ought to go from here?"
"That depends a good deal on where you want to get to," said the Cat.
"I don't much care where—," said Alice.
"Then it doesn't much matter which way you go, " said the Cat.
"—so long as I get somewhere," Alice added as an explanation.
"Oh, you're sure to do that, if you only walk long enough" concluded the Cat.

In the early 1990's the Modeling and Simulation (M&S) community was traveling in a direction similar to that of Alice: we knew we wanted to go somewhere but we didn't know exactly where. As Department of Defense (DoD) resources shrank, and the use of M&S as an analytical tool expanded, it became obvious that we could no longer continue to "walk long enough." To meet this challenge, personnel in the Army applied a systems approach to the problem. We examined the current state of the Army's M&S environment, or more simply put, where we were. Next we articulated the desired state, or where we wanted to be, in the form of an objective M&S environment. We then set about establishing a course of action to bridge the gap between the current state and the desired state. This implementation embraces the development of M&S standards through a bottom-up approach with decentralized authority. This article will describe the Army's process to develop and promulgate technical standards and how this endeavor supports Simulation Based Acquisition (SBA) and Verification and Validation (V&V) and Accreditation.

In the early 1990's the Modeling and Simulation (M&S) community was traveling in a direction similar to that of Alice: we knew we wanted to go somewhere but we didn't know exactly where.

What Is An Army M&S Standard?

Webster's II New Riverside University Dictionary defines standards as "a rule, principle, or measurement established by authority, custom, or general consent as a representation or example." Following this definition, the Army's applies the term M&S standard in the broadest context to include procedures, practices, processes, techniques, algorithms and heuristics. Standards for M&S cover a variety of topics and the type and source of relevant standards will vary with each of the 19 standards categories. The standards categories represent the M&S functions that, taken as a whole, cover the technological spectrum.

Simply put, the Army seeks to develop standards to improve M&S interoperability and credibility while also increasing commonality and reuse. Through the development of M&S standards the Army hopes to:

- Enable simulations to provide or accept services from one another thus making them more interoperable;
- Improve the credibility or acceptance of M&S representations;
- Increase commonality in the depiction of the synthetic environment; and,
- Establish a baseline for reusing standard algorithms and heuristics in future simulations.

The Army's Seven Step M&S Standards Development Process

The Army's development of M&S standards is consensus-based by choice. M&S technologies evolve at blinding speeds. Some technological niches turn over in a matter of months. Technological,

(See **M&S,** *p. 12)*

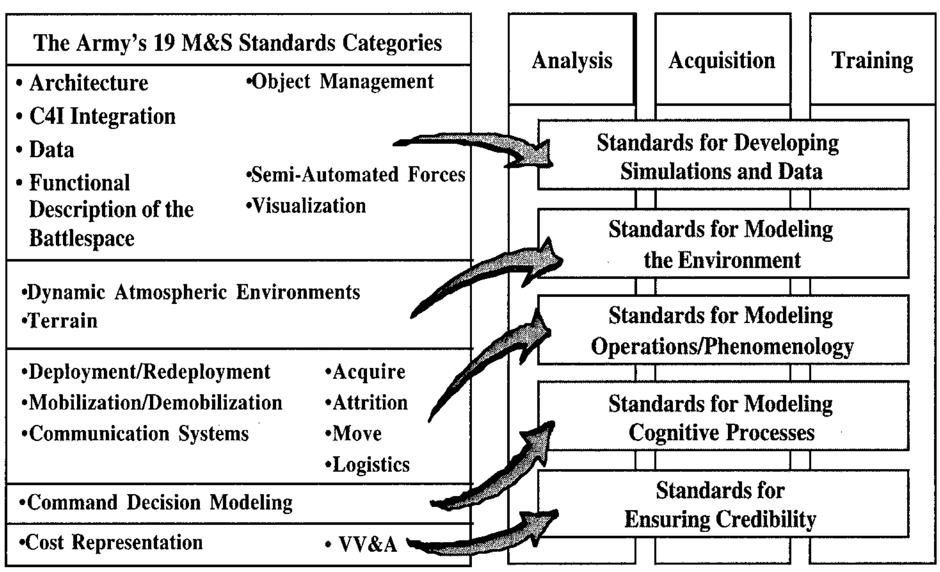

FIGURE 1. The Army's M&S Standards Categories

M&S
(continued from p. 11)

procedural and application advances take place within a myriad of organizations in the Army, and throughout the government, commercial and academic sectors. Attempting to centralize the authority for establishing standards, without devoting major resources to the effort, would not enable the Army to remain a M&S community leader. Rather, it could place the Army permanently behind the rest of the M&S community. No single Army office or organization is capable of effectively investigating and making the necessary decisions to evolve Army models and simulations that keep pace with the rest of the industry. By keeping the process consensus-based, those decisions are in the hands of the real Army M&S experts.

Build Teams. Subject matter experts from various organizations throughout the Army are appointed to serve as Standards Category Coordinators (SCCs). They are not executive agents. They serve as the leadership for developing M&S standards within their individual category. They are empowered to develop their teams by drawing on the mix of talents and expertise needed in their specific area. Team composition is interdisciplinary and knows no organizational boundaries. Membership is based on inclusion rather than exclusion. Each team has an electronic mail reflector, which permits a wider community to participate in the development of future standards while minimizing travel.

Define Requirements. The second step is to define requirements. To assist in this and the next three steps the Army has developed the Standards Nomination and Approval Process (SNAP) at http://www.msrr.army.mil/snap. At the heart of SNAP is the Standards Requirement Document (SRD). The SRD, an online form, is the first step in developing a new Army M&S standard; refining an existing standard; or nominating an accepted M&S procedure, practice, process, technique, algorithm or heuristic to become a standard. With only limited resources to devote to the development of standards, it is essential to keep the work of the team focused on the most important issues. Once an SRD is received, the Army Model and Simulation Office (AMSO) coordinates validation of the proposed requirement with the appropriate SCC and other key players to ensure that the proposal supports a community need. After validation is completed, the initiator is provided feedback. A proposed standard could be an excellent idea but may fail to fit a "market niche." If the proposal is approved, it then moves on to the next step in the process.

Once an SRD is received, the Army Model and Simulation Office (AMSO) coordinates validation of the proposed requirement with the appropriate SCC and other key players to ensure that the proposal supports a community need.

Develop Standards. This step is the crux of the Army's M&S Standards Development Process. The wider the involvement of experts across the M&S community, the more likely each team will capture, adapt, or develop those procedures, processes, techniques, algorithms and heuristics — as well as "best and current practices" — that warrant becoming an Army M&S standards.

Achieve Consensus. After the standard has been developed, the next step is to achieve consensus. SNAP is the primary vehicle used by the teams to "hammer-out" issues and achieve consensus on a draft standard. SNAP monitors all electronic mail traffic on the reflectors and as part of its database maintains a copy of every reflected message sent. This useful feature allows one to review the on going debate on one or more draft standards, enter the debate at any time during the process, and eliminates the need for team members to personally maintain a copy of every electronic mail message. Each draft standard may go through several iterations before being embraced by the team. Because the process is continuous and iterative, the community more readily adopts standards they feel can be modified and improved over time.

Obtain Approval. Once consensus has been achieved, a panel of Senior M&S subject matter experts then reviews the draft standard. SNAP automatically sends an electronic mail message to the appropriate reviewers. The message contains a "hot-link" to their individual voting page along with information on the draft standard. Senior reviewers may either vote "Yes" or "No." If they vote "No" a comment field must be completed or the vote will not be accepted. Every effort will be made to resolve the senior reviewer's concerns prior to the closure of voting. After voting has concluded the proposed standard and all comments are either forwarded to the Deputy Under Secretary of the Army (Operations Research) (DUSA(OR)) for approval or returned to the standards category team for additional work.

Promulgate Standards. Every approved Army M&S standard will be registered in the Army Standards Repository System (ASTARS) at http://www.msrr.army.mil/astars. For each entry, you will find information about the standard and a point-of-contact. To the maximum extent practical standards will be made available electronically. Standards in ASTARS can be password-protected when access needs to be limited. However, classified standards will not be stored in the current version of ASTARS. Those standards not available for public release will follow the release procedures for M&S described in Army Regulation 5-11. Each SCC has a Home Page to provide specific information pertaining to their category. Information on all the aspects of M&S Standards can also be accessed from both the AMSO Home Page (http://www.amso.army.mil) and the Army Node of the Modeling and Simulation Resource Repository (MSRR) (http://www.msrr.army.mil).

Educate. Educating and assisting modelers and users is accomplished concurrently with the other steps. Once a standard has been approved, the team begins educating the M&S community on the availability, applicability and use of the standard. The more active the standards category team, the more educated the community.

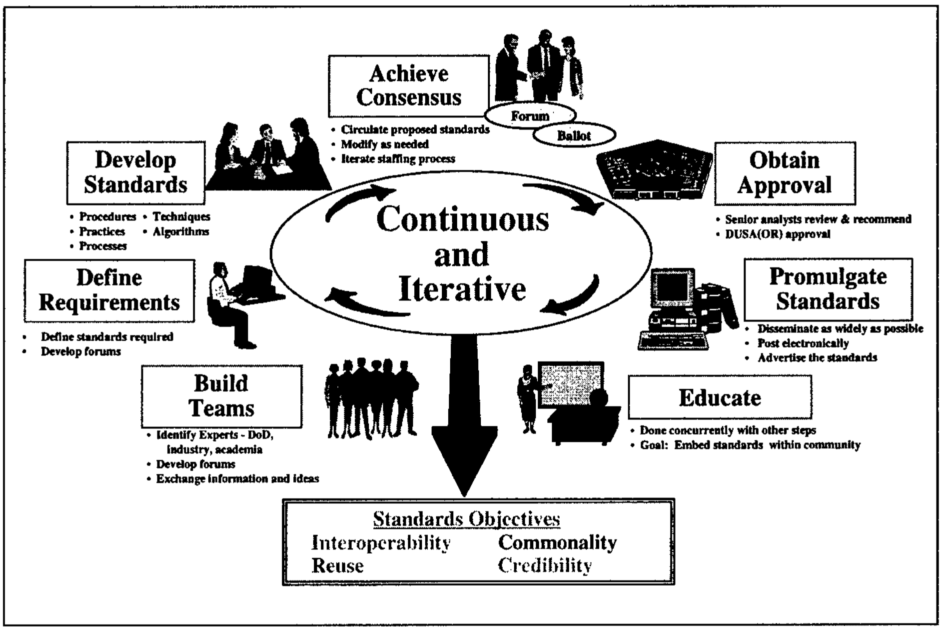

FIGURE 2. The Army's M&S Standards Development Process

How Do Standards Expand M&S as an Analytical Tool?

The vision for SBA is "to have an acquisition process enabled by robust, collaborative use of simulation technology that is integrated across acquisition phases and programs." The employment of M&S standards is a key component in achieving this vision. The Army's Standard Development Process provides a systematic approach to the development, use and reuse of the components, as well as, the complete M&S software. This provides the opportunity to substantially reduce time, resources and risk associated with the acquisition process. By using approved standards, M&S developers have a solid foundation upon which to build. The developers can begin their design efforts by querying ASTARS to see if a standard presently exists to meet their needs. If not, an SRD can be submitted to either modify an existing standard or create a new one for this particular use. In addition, the Army's M&S Standards Development Process provides a forum for M&S members of the analytical, acquisition and training communities to leverage one another's work and the potential to promote Integrated Product and Process Development throughout a systems' product lifecycle.

The use of approved M&S standards also benefits V&V as well as Accreditation. Via the Army's M&S Standards Development Process, verification is expedited by the fact that the components of the M&S have been previously examined to ensure conformance to sound software-engineering techniques. Validation is enhanced because the standards have already been reviewed by subject matter experts and senior analysts to ensure the standard in question is a valid representation of its real world counterparts. All approved standards will be documented thus providing both V&V and Accreditation agents information on the utility and limitations of a standard. In short, by using approved standards, V&V and Accreditation become less time consuming and expensive.

Conclusions

The objective of the Army's M&S Standards Development Process is to create an environment that promotes the sharing and reuse of M&S procedures, practices, processes, techniques, algorithms and heuristics. It is not intended to create a set of written standards that will sit unused in ASTARS. The continuous and iterative nature of the process permits the Army M&S community to keep pace with, rather than react to, technological advances. Via SNAP and ASTARS, the Army moves progressively closer to its goal of developing "a comprehensive set of standards that facilitates efficient development and use of M&S capabilities" and reduces the gap between the current and the desired state.

By using approved standards, M&S developers have a solid foundation upon which to build. The developers can begin their design efforts by querying ASTARS to see if a standard presently exists to meet their needs.

Resources

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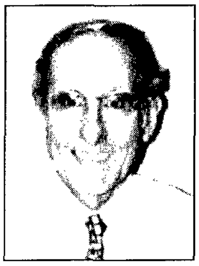
Alternative Measures of Performance for Testing Command and Control Systems



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The Joint Interoperability Test Command (JITC) recently completed Operational Test (OT) for the Global Command and Control System (GCCS) Version 3.0, the current Department of Defense Command and Control System of Record. To achieve testing economies and to overcome specific challenges, JITC implemented surrogate Measures of Performance (MOPs) that have broad applicability to other command, control, communications, computers and intelligence (C4I) systems.

Surrogate Measures for Reliability, Availability and Maintainability (RAM)

Traditional measures of RAM are Mean-Time-Between-Operational-Mission-Failures (MTBOMF), Operational Availability (A_O), and mean-time-to-repair (MTTR). All of these traditional measures require a strict dichotomy between system operating time and system down time; in other words, they require the system to be either "up" (operating) or "down" (not operating).

In the highly distributed, client-server, multiprocessor environment of GCCS, the dichotomy between operating time and down time does not exist. Instead, many levels of degraded operation exist between up and down. Further, the characterization of the "system" is blurred because the system may be defined as:

- The entire network of over 600 sites.
- A single site, many of which have unique configurations.
- A user workstation, of which there are three distinct types and several unique configurations.

As a result, the GCCS community selected alternative characteristics in lieu of the traditional RAM measures. Specifically, the user community emphasized requirements for accessibility, consistency and dependability.

Accessibility is the ability of users to log on and begin executing processes in support of mission operations. Test measures were time to log on and time to access applications. The assessment considered both local and remote (dial-up) access; it also considered multiple workstation types and multiple applications. The analysis focused on timeliness in operational terms (in other words, can the user access the system in time to support mission accomplishment).

Consistency is the ability of the system to provide the same results to a given process regardless of where it is initiated and, if the underlying data has not changed, regardless of when it is initiated. The test measure was comparison of system output for identical processes. To ensure the test addressed user concerns, the test focused on specific applications nominated by the user community.

Dependability is the ability of the system to complete user-initiated processes to the user's satisfaction. Test measures were frequency and duration of workstation outages. These measures focused on the ability of the user to complete assigned mission tasks. The analysis considered three types of outages: corrected by the operator, corrected by site personnel other than the operator and corrected by off-site personnel. This approach was selected to facilitate analysis of any supportability shortfalls.

Table 1 provides a summary comparison of the traditional and surrogate measures.

The overall benefits of these surrogate measures were:

- The test command avoided the pitfalls associated with traditional RAM measures used in previous tests.
- The test focused on issues of primary concern to the user.
- Test results provided a baseline for comparison to similar results for future versions.

Summary. The traditional RAM measures may not apply in complex distributed systems. In such cases, the test community should be open to applying meaningful surrogate measures that support the evaluation from the user perspective. Accessibility, consistency and dependability are valid candidate measures and should be considered in future tests.

Measuring the Ability of the System to Support User Missions

The test command was faced with two significant challenges in the operational evaluation:

- ***"Soft" criteria.*** For the most part, the user-defined criteria were subjective and did not have well-defined quantitative thresholds.
- ***Comparison to previous version.*** The fundamental requirement for fielding Version 3.0 was to match the functionality of the previous version. However, a quantitative performance baseline for the previous version did not exist.

To meet this challenge, the testers, in concert with the user community, established a test measure to assess the ability of the system to support user missions. This broad-based measure, known as Subject Matter Expert (SME) assessment of mission tasks, supported evaluation of three of the five critical operational issues. As a result, the TEMP identified it as the primary measure of performance for the system.

Figure 1 illustrates the approach for incorporating the SME assessment throughout all phases of the test and evaluation process: test planning, test execution and test analysis and reporting.

The user community participated in developing the mission task list, selecting those tasks that were most critical. Three

Table 1. Comparison of Traditional and Surrogate Measures

Traditional Measures	Surrogate Measures
Reliability MTBOMF = # of operating hours / # of operational mission failures **Availability** A_O = # of operating hours / (# of operating hours + # of down hours) **Maintainability** MTTR = # of hours in repair / # of repair actions	**Accessibility** Time to log on = Elapsed time from "Password Entry" to "Desktop Ready" (System Ready to Respond to User Requests) Time to access applications = Elapsed time from "Icon Click" to "Application Window Ready" **Consistency** Manual comparison of printed output reports **Dependability** Frequency of workstation outages = # of outages per day Duration of workstation outages = elapsed time from "Outage (Lockup) Perceived by User" to "Functionality Restored"

types of mission tasks were assessed:

- ***User mission task.*** A staff action that requires system support to complete; it has defined product and takes about one to four hours to complete. Examples:
  - Develop and enter common-user air movement schedules.
  - Produce a non-combatant evacuation list for the planned area of interest.
  - Produce an intelligence resources report.
- ***Installation mission task.*** A function performed by a system administrator or other site personnel to install and configure the system in preparation for sustained operations. Examples:
  - Install and de-install software segments.
  - Set up and maintain user accounts.
  - Establish local site configuration.
- ***Sustained operations mission task.*** A function performed by site personnel to support sustained operations of the system. Examples:
  - Access audit capabilities.
  - Establish and maintain database structure.
  - Administer and monitor the network.

For user mission tasks, the SME was a system user at the test site (for example, a staff officer who uses the system products to support mission accomplishment); in general, the mission task SME was not the workstation operator who performed the task. For installation and sustained operations mission tasks, the SME was a member of the GCCS team at the test site who was sufficiently knowledgeable in the function to make the assessment.

SMEs observed and assessed each task. For user mission tasks, the assessment was based on the timeliness, accuracy, completeness and usefulness of the mission task output/product (in other words, on the "goodness" of the information provided by the system). SMEs used this rating system to assess the results:

- ***Fully successful.*** Product is sufficiently timely, accurate, complete, and useful. Fully supports mission accomplishment by the intended recipient.
- ***Marginally successful.*** Product is accurate and timely; it supports mission accomplishment. However, the user is required to perform workarounds to generate or use the product.
- ***Unsuccessful.*** No product, product cannot be used by the intended recipient for the intended purpose, or the product is too late or inaccurate to support the mission.

For installation and sustained operations tasks, SMEs assessed both the success and the ease of the task considering training, documentation, timeliness and other factors.

The benefits of this assessment approach were:

- Challenges associated with "soft" requirements and the lack of quantitative thresholds were overcome.
- The user community was involved early in the test process, ensuring the evaluation

(See **TESTING,** *p. 35)*

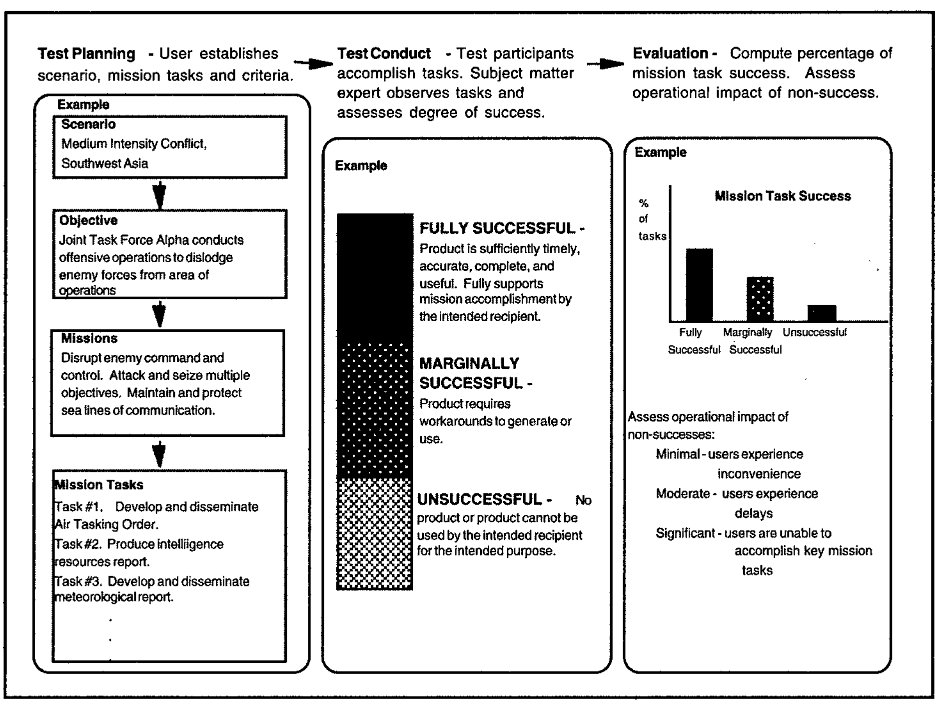
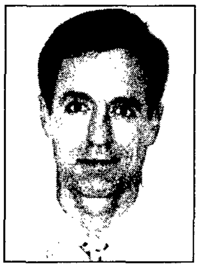


Figure 1. Measuring Mission Task Success

Building Complexity into Biomedical Models



Dr. Matthew Reardon

Introduction

Because human response Input- Output (I/O) relationships seem to be tremendously complex, not easily amenable to neat analytic solutions, and include stochastic and chaotic characteristics, they are difficult to comprehensively model and simulate with high degrees of fidelity and predictive accuracy. Nevertheless, relatively simple, operationally useful, first-order models of soldier responses to environmental stressors and survivability threats have been implemented and integrated into military applications. The seemingly intractable complexities of the human system have been successfully managed by various complexity reduction techniques such as abstraction, domain restriction, simplifying assumptions, effects aggregation, order reduction, lookup tables and rules-of-thumb.

Simplified soldier response models are a practical necessity for many applications but they can also serve as platforms for the development of models having greater complexity and realism. Complexity can be added to increase a model's scope and usability, explore second and higher-order effects and simulate anticipatory and delayed responses, feedback modulation, and other important intrinsic human capabilities such as noise filtering, prediction and pattern recognition.

Elements of Complexity

There are numerous aspects to complexity in modeling the human element. Here we review some of the latent complexities in basic physiological and cognitive system transfer functions.[1] There are additional sources of human complexity such as multitasking, communications, decision making and motivation that are not discussed in this paper.[2, 3]

Number of Variables

Simple models, almost by definition, have few predictor and response variables. Conversely, the greater the number of variables, the more complex the model. However, as multistep regression analysis often demonstrates, adding more independent variables alone does not always significantly improve a model's predictive capability.

Additional dependent variables can expand the scope of a model's usability but often requires a concomitant increase in the number of input variables and does not itself improve a model's resolution.

Non-linearity and Interaction

The characterization of human system responses ranges from almost linear to highly nonlinear. Although, for many applications, nonlinear responses can be adequately approximated using piecewise-continuous linear I/O models, high fidelity representations may require implementation of more accurate and realistic nonlinear system descriptions.

Nonlinear modeling terms are not as problematic from the algorithmic viewpoint as they are when included as components of dynamic-response models. In such instances, they can make obtaining closed-form solutions very difficult (requiring an expert in applied mathematical methods) or impossible. Nonetheless, even simple soldier response prediction algorithms often include nonlinear terms. Perhaps the most frequent nonlinear representations are exponential functions of input or intermediate process (state) variables.

Compartment models are frequently used to model dynamic physiological processes and are therefore typically formulated as systems of coupled linear differential equations.[4] These are relatively straightforward to interpret and implement. A difficulty, with adding nonlinear terms to such models, however, is that the resulting system of equations will often become analytically intractable. However, a numerical solution can be obtained using software algorithms (often very complex when optimized for robust manipulation of ill-conditioned matrices). A significant disadvantage of not being able to derive a closed-form solution is that results from numerical methods cannot be directly verified.

Another point to consider is that nonlinearities due to use of higher powers of independent variables can improve predictive precision to a certain degree. In many cases, however, a lower-power cross-product term will have greater effect in improving a model's predictive capability. First-order cross products can also be interpreted as representing the effects of variable, or factor, interactions. The meaning of higher-power terms is usually more difficult to discern.

Adding nonlinear terms to an established algorithm is usually trivial, in itself. However, it may be costly due to the need to re-determine coefficient values to properly apportion linear, power, and interaction effects. Also, robust coefficient determinations for models with interaction terms can only be assured if data used for coefficient identification were derived from studies explicitly designed to evaluate interaction effects in statistically valid ways.

Time Invariance

The human I/O processing mechanism is usually not time invariant because responses to inputs typically differ as functions of time of application of stimuli. Training and habituation make many some input/output relationships approximately time invariant, however, other responses remain very time dependent. In many cases, however, time is actually a surrogate for number of previous exposures (experience factor). That is, the coefficients for the predictor variables are functions of time or frequency with which a particular input profile has been applied.

Causality

Causal systems generate outputs based only on current, or previous, but not future, or anticipated, inputs. Because humans naturally formulate and use mental models to facilitate estimation, prediction and decision making, situational responses are functions of not only present and past exposures but also of predicted future events. In this sense, human system responses involving cognitive processing are not always causal. This is an additional source of complexity that can be addressed when striving to develop accurate soldier response and decision making models.

Feedback

Systems often contain or are part of feedback mechanisms. The nature of feedback (positive or negative) determines the nature of system responses to both deterministic inputs and random perturbations. Feedback response characteristics (e.g., damped or undamped) are determined by constitutive properties incorporated mathematically into coefficients and parameters. A soldier, for example, utilizes direct sensory and model-based feedback to direct and adjust behavior and achieve objectives and specified levels of performance despite changes in internal parameters. Hence, closed loop soldier models are preferred over their open loop alternatives for high fidelity, constructive soldier-based simulations.

Uncertainty

Human response models that only use mean values for coefficients and parameters are effectively deterministic. Associated second order statistics for these values are required to create stochastic human models that can be used for Monte Carlo simulation. Surprisingly few models provided such data, unnecessarily limiting their application. The assumption regarding parameter variability is that the distribution is Gaussian (therefore obviating the need for higher-order cummulants) and that the distributions do not vary as functions of time or other variables (i.e.; the statistics are stationary). It is doubtful that most human processes are exactly stationary. Therefore higher fidelity will occur with nonstationary models.

Additionally, human responses to identical sequences of conditions and events typically vary considerably between individuals. Sources of such interpersonal variances include myriad differences between individuals in basic characteristics and experience as well as differences in sensitivity to changes in external and internal variables on cognitive, affective and physiological responses.

Optimization

Humans act instinctively in attempts to optimize state trajectories based on qualitative minimization or maximization of various subjective functions of sensations and potential consequences. For example behavior patterns are directed toward minimizing effort, energy, task completion time, distance, expense, inconvenience, stress, distress, etc. Alternatively, behavior is directed toward maximizing convenience, comfort, recognition, awards, recreational time, etc. Behavior, however, is usually driven by efforts to simultaneously minimize adverse consequences and maximize beneficial ones.

Software-implemented soldier models typically act deterministically according to scripts or prescribed rules. However, real soldiers are more complex and tend to act in ways that minimizes effort and exposure to stressors. Humans attempt to efficiently reach objectives by qualitatively optimizing a subjectively weighted sum of gain and cost functions. We know, however, that this process does not always work that well. There may be considerable inter-personal variability regarding selected optimization functions as well as variability in their relative weightings.

Noise Filtering

Humans routinely filter sensory input to reduce the effects of noise and improve the effective signal to noise. Therefore human response models can be made more realistic by appropriately including this capability. Filtering noisy input improves dynamic performance.

Verification and Validation

Verification of complex human models in many cases will not be possible since the theoretical or mathematical foundations for much of the nonphysiological components of human models are inductive rather than deductive. Hence the best that can usually be done is to draw upon validated methods or forms and validate the performance of the subsequent model. Unfortunately, however, adding even a small amount of complexity to a model may make it impossible to effectively validate. This can occur, for example, if a model's dimensionality requires a combinatorially large number of studies to span the operationally required validation envelope.

These problems do not obviate the usefulness of complex models. They can still be useful for testing concepts and generating hypotheses that can be specifically tested in focused studies. Such models can also be used to evaluate sensitivity of human system responses to changes in characteristics (coefficients and parameters), defining the statistical characteristics of model outputs, and as a basis for reverting to an extended simplified model using complexity reduction techniques such as linearization.

(*See* **BIOMEDICAL MODELS,** *p. 32)*

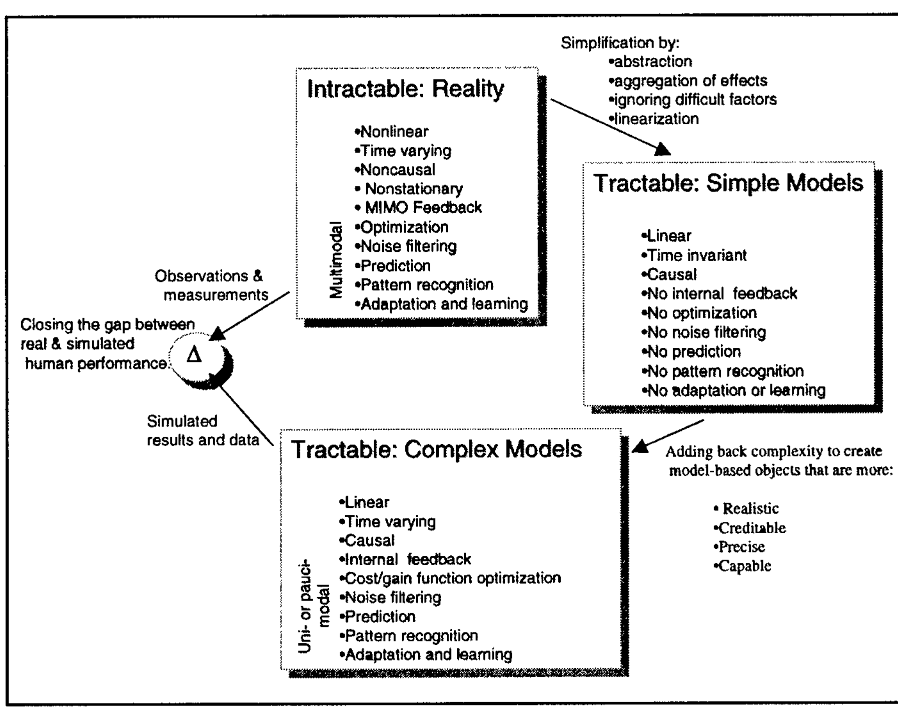


Figure 1 - Building Realistic Human Performance Models by Adding Complexity to Simple Models

Working Groups/Composite Groups and the 67th MORSS

CDR **Kirk Michealson**, WG/CG Coordinator
MAJ **Steve Horton**, Deputy Site Coordinator

The 67th MORSS will be held 22-24 June 1999 at the United States Military Academy, West Point, NY, with a theme of *Focusing Military Operations Research: From our Heritage to the Future.* The Announcement and Call for Papers (ACP) has already been sent out, and you should have your copy with the details for the Symposium. The ACP has additional information on preparing abstracts, contact information of the Composite Group and Working Group Chairs, and discussion on areas of interests for each of the working groups. If you haven't received your ACP yet, please call **Cynthia Kee-LaFreniere** or **Christine Parnell** in the MORS Office to request one [(703) 751-7290], or you can check the 67th MORSS link from the MORS home page (http://www.mors.org/).

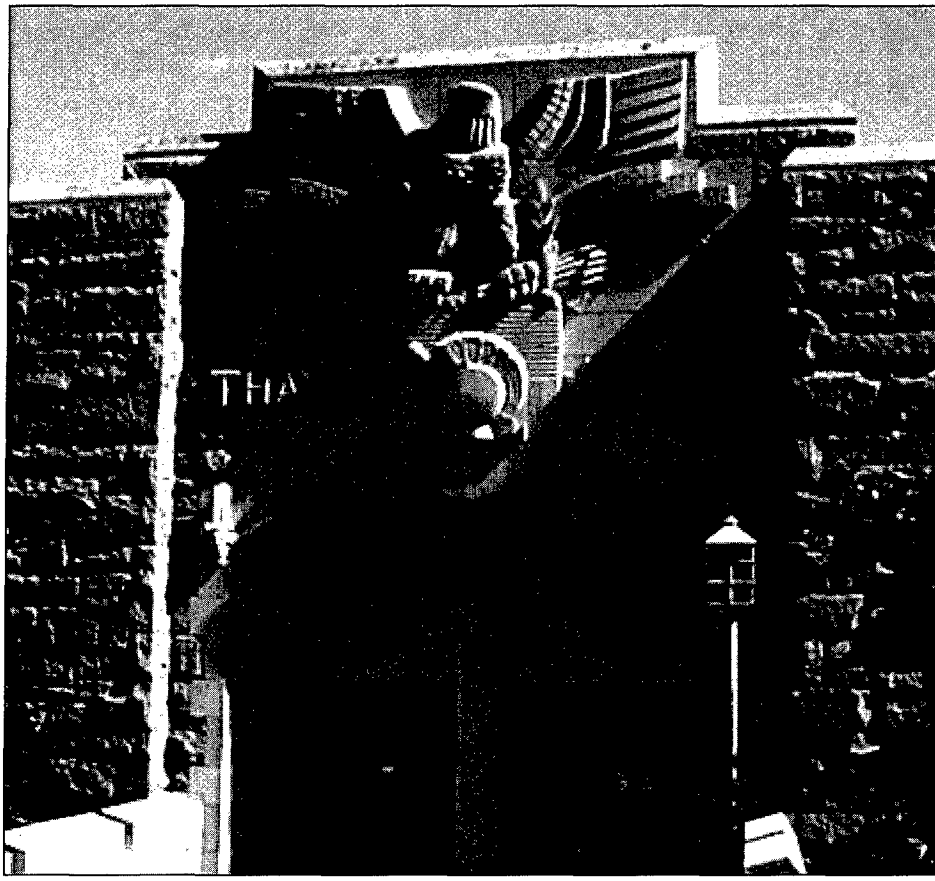


Figure 1. Thayer Hall

Figure 2. Typical Thayer Hall Classroom

Abstracts for all proposed presentations are due by 22 January 1999. Send yours directly to the Working Group or Composite Group Chair you believe would be most interested, or to the MORS Office, if you are uncertain, and they will forward it to the appropriate Chair. The quality of papers determines the overall success of the Symposium. Do not hesitate to present a paper. A fully-developed paper is not required, just a presentation pitch. Also, the research does not need to be completed or a conclusion reached, we encourage works in progress — peer critiques are excellent! This is a good way to receive "free" suggestions from your peers on how your analysis is going and how you can make it better.

Like the 66th MORSS, the Composite Group and Working Group Chairs will again have eight group sessions, all in the 0830-1000, 1030-1200 and 1330-1500 timeslots (except for the 0830-1000 timeslot on Tuesday when the Plenary Session is scheduled). The Special Sessions are also in the same timeframe as last year, from 1530 to 1700 daily. To

view a summary agenda/ session schedule for this year's Symposium, please look at the 67th MORSS link on the MORS home page.

From the WG/CG perspective, we are looking forward to this year's Symposium at West Point. The classroom facilities there are ideal for this purpose. Not only will almost every WG and CG session be conducted on one floor of one building, but the rooms themselves are all outfitted with powerful computer equipment and software.

The WG and CG sessions for the 67th MORSS will be held in Thayer Hall (see Figure 1). Most classrooms in Thayer Hall are configured to seat 20 cadets at small student desks. While there are some larger rooms available for the CG sessions and for some of the larger WGs, many of the WG sessions will be conducted in these 20 person rooms. We intend to add a few chairs and remove enough desks to boost the capacity of these rooms for MORSS to 30 or so. Figure 2 shows a typical Thayer Hall classroom in use.

Every WG and CG presentation room contains a Pentium 90/100 PC with multimedia that is connected to the network. Currently, these PCs operate with Microsoft NT 4.0. The software load includes Microsoft Office '97, so PowerPoint presentations will be easy to handle. In addition, these rooms all have an Epson projection device that projects a large and clear image of the computer monitor on to a screen. A hand-held remote control allows the briefer to perform all mouse functions from anywhere in the room. This system is easy to learn and is a very effective means of presenting information. There is also a VHS format VCR that runs through the projection device available in each room. Finally, each room has a sturdy and well-used overhead projector that can be used by anyone so inclined. Figure 3 shows the presentation system in operation.

West Point intends to provide electronic storage space for unclassified PowerPoint presentations that presenters want to e-mail to the site, and they also plan to have a small number of computers available for presenters who wish to update their presentations during the Symposium. The details of these procedures will be published later. None of the computers are certified for classified operation, so classified presentations must either be in hardcopy form (either mail them or hand carry them) or on the presenter's own (certified) laptop. Please do not attempt to e-mail any classified material to West Point. Details regarding classified presentations will be published at a later date.

Finally, West Point intends to make extensive use of the internet to disseminate information. General information about USMA is available at http://www.usma.edu/. General information about the 67th MORSS is available at http://www.mors.org/. The site committee stands ready to do their part to make the 67th MORSS the best ever.

If you have any doubts at all about presenting a paper, have any other questions, or have not received the ACP, please contact the MORS Office at (703) 751-7290 or the WG/CG Coordinator, CDR **Kirk Michealson**, at (703) 697-0064. ✪

Keynote Speaker Confirmed!

GENERAL JOHN N. ABRAMS

Commanding General,
United States Army Training and Doctrine Command,
has agreed to be the Keynote Speaker
at the 67th MORS Symposium, USMA
23-25 June 1999

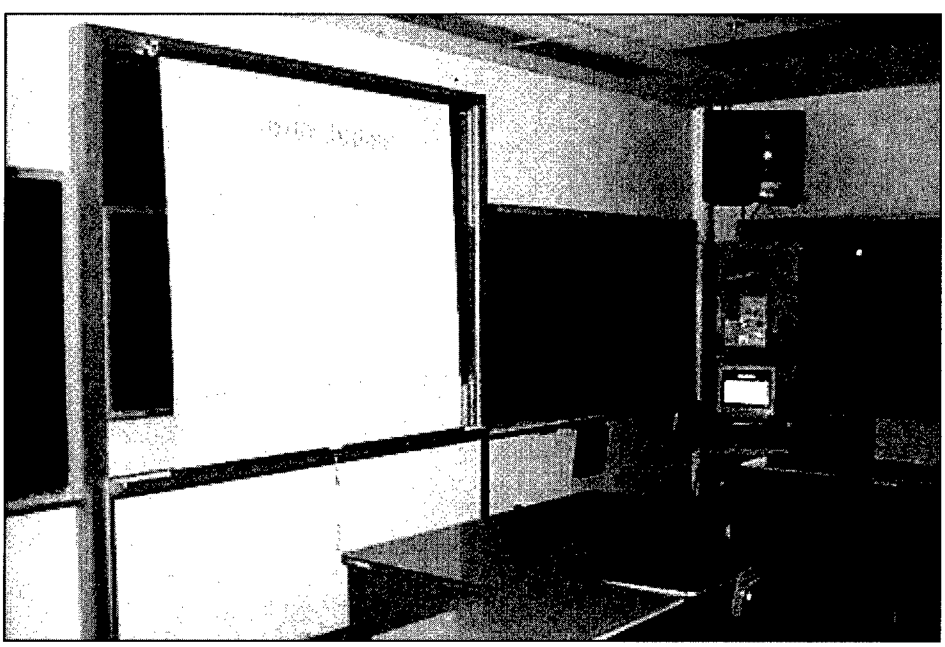


Figure 3. Classroom Presentation Equipment

Is "Non-Selection" the Same as "Elimination?"

Dr. **Donald Barr**
US Military Academy

Abstract

I propose a rough model that suggests there is a significant difference between *non-selection* and *elimination* as typically practiced by "selection" committees and other choice processes. I argue that Army officer selection boards appear to be operating as elimination processes. This has interesting implications for individual officers aspiring to higher ranks, and suggests this leads to a corps of retained officers having certain qualities. Applying the elimination process in the succession of boards involved in selecting officers for increasing ranks amounts to a sequence of successive ("compounding") truncations of a parent distribution. This contributes to having a set of senior officers whose ratings are sometimes said to be "nearly indistinguishable."

Committees formed to "select" the most attractive from a group of candidates in many cases actually function by *eliminating* the non-attractive candidates. I shall argue that the sets of candidates chosen by these processes are quite different. For example, the committee formed in a university mathematics department to select the calculus textbook to be adopted for next year's classes typically begins by looking for objectionable attributes in the candidate texts. Any text found to have an undesirable (or even unusual) quality is usually eliminated from further consideration. What remain are candidates having no unusual characteristics; the elimination process tends to generate finalists that are similar and "middle of the road" in every respect considered. In addition to textbook "selection" committees, examples of elimination processes include personnel departments recruiting to fill mid-level openings in a corporation and how we select a rental video for viewing by the family.

A crude model can be stated in terms of the score T_{ij} of candidate i in dimension (or attribute) j, where we agree to define scores so that "bigger is better" in all cases. The set E of survivors of the elimination process is, roughly, $E=\{i:\forall j, T_{ij} \geq g_j\}$ where g_j is the lower bound of good performance in dimension j. For an individual to remain in the set of survivors, he or she must have no instances of less than good performance in any dimension.

Selection processes, on the other hand, tend to seek outstanding (and sometimes unusual) qualities and even to trade these off against mild shortcomings. The selection process tends to generate finalists that are quite different. Every day examples of selection processes include sports "winners", such as horses showing in a day of racing at a given track, or selection of a mutual fund based on performance over the past year. Perhaps Darwin's *natural selection* is truly a selection process. As yet another example of selection, the student admission process here at the US Military Academy evaluates candidates in areas such as grades, SAT scores, leadership, sports and service. Admissions officers tend to look favorably upon a candidate having outstanding qualifications in one or more of these areas, even though he or she does not score exceptionally high in other areas. Indeed, there is a deliberate effort to admit candidates so as to form a corps of "qualified" cadets having a wide variety of attributes. (Admittedly, there is an initial elimination of candidates whose SAT scores are below some threshold. Thus the overall process is actually elimination, followed by selection.)

Committees formed to "select" the most attractive from a group of candidates in many cases actually function by *eliminating* the non-attractive candidates.

In the selection cases, there may well have been moderate (or even poor) performance in various dimensions, or at other times, but spectacular performance in a given dimension over the period considered may lead to selection. In terms of our model, the set S of survivors in a selection process may be something like $S=\{i:\exists j, T_{ij} > o_j\}$ where o_j is a bound defining outstanding performance in dimension j.

It is clear from their defining conditions that E and S are quite different. To illustrate, suppose there are three candidates being assessed with respect to two attributes. Let us identify candidate 1 by his vector of scores $(T_{11}, T_{12}) = (5, 4)$, and similarly for candidates 2 and 3 with scores (2, 17) and (8, 2), respectively. Suppose $g_1 = g_2 = 3$ and $o_1 = o_2 = 10$. With an elimination process, candidate 1 would be the sole survivor (i.e., the only member of E), whereas candidate 2 would be the only member of the selected set S.

By our crude model, the process of selecting the candidates to be excluded (i.e., "selecting out") gives an excluded set defined by $O=\{i:\exists j, T_{ij} < g_j\}$. Since negation of the condition defining O gives the condition defining E, it follows that O and $\overline{E}$ (the complement of E) are the same. That is, eliminating candidates is equivalent to selecting them out. It is therefore somewhat surprising that the sets of *retained* candidates resulting from elimination and selection are so different. (Interestingly, when only one attribute is under consideration, definitions of S and E differ only in the values of the thresholds o and g. Presumably in some situations these would be made to coincide, in this case, in order for the processes to generate the desired yield of retained candidates.)

I believe promotion boards for officers in the US Army appear, as a first approximation, to be operating more like elimination boards than selection boards, partly in response to the downsizing effort.[a] This has clear implications for both the officers aspiring to higher ranks and the nature of the officer corps. For the indi-

vidual officer, it means he or she may choose to operate in accordance with the "maximin" principle; the officer must not allow any "wart" to appear in his or her performance record. Thus, a battalion commander may feel it necessary to spend 14-hour days in the field, 7 days a week, to make sure there are no "problems." Such an officer commanding a unit at the NTC may be reluctant to "innovate" or "experiment;" rather, such commanders may tend to "play it by the book," because it is risky for them to deviate from doctrine. (Being whipped by the OPFOR is certainly not the fault of a commander rigorously following doctrine!)

Implications the elimination process has for the officer corps are interesting. First, there is a perception that the survivors may tend to be "conservative," and "non-risk takers." Second, the sequence of eliminations the survivors must endure as they undergo boards and other "required" assignments contribute to compounding the effects. This leads to an officer corps in which the individuals are nearly indistinguishable especially in the upper ranks, as we quantify in the following section.

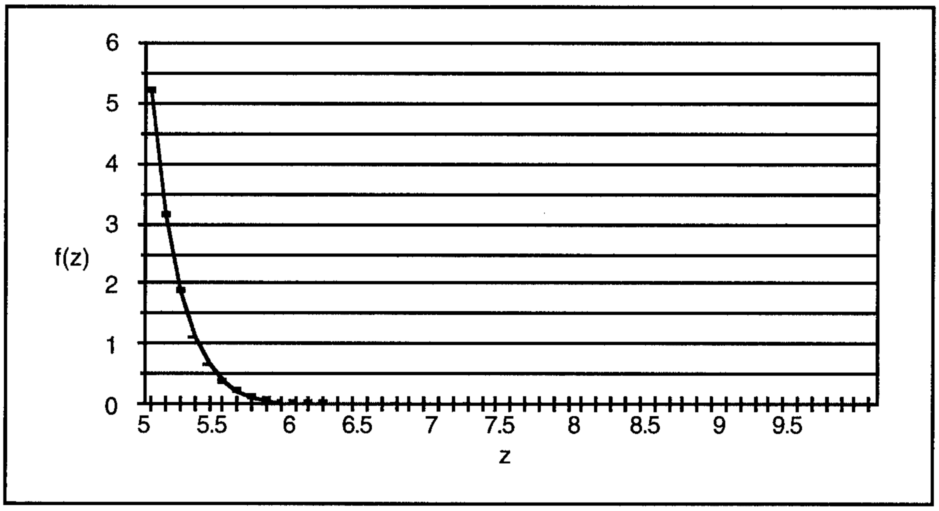


Figure 1. Plot of the density of a N(0,1) population truncated below at 5.0. The mean of this distribution is approximately 5.2 and the variance is approximately 0.03.

Compounding Elimination Effects: Preliminaries

Let us consider a single dimension of performance, and investigate the effects of eliminating candidates failing to achieve "good enough" performance. We want to examine the population that remains after such elimination, and to consider the effects of repeated eliminations by a sequence of "selection" boards for the successively higher ranks. Let us first enjoy some preliminary ideas based on simple calculations with normal distributions, assuming, as a crude model, that the original population of second lieutenants has normally distributed performance scores. For illustration purposes, we can assume the normal distribution has mean 0 and variance 1. The elimination process leads to a surviving population with a truncated normal distribution; all individuals with scores below a given value t have been eliminated.

Let Z be a standard normal random variable truncated below at a fixed point, t. That is, one could generate a sample value of Z by sampling from a N (0,1) population until a value greater than t is obtained; that value is retained as the outcome z. Then the density of Z is $f(z) = c(t)e^{-z^2/2}; z \, 3 \, t$, and, of course, f(z) is zero for z < t; here $c(t) = 1/[\sqrt{2\pi}(1 - \Phi(t))]$, where Φ is the standard normal cumulative distribution function (CDF). This density does not have the shape we might expect, especially for large truncation points. For large t, the probability density is quite high just to the right of t, and it decreases very rapidly toward zero as its argument increases. A plot of a truncated normal density, for t = 5, is shown in Figure 1. Thus for large t we would expect the mean of Z to be just above t and the variance of Z to be near zero. The mean and variance of Z are $E(Z) = c(t)e^{-t^2/2}$ and $V(Z) = c(t) \sqrt{\frac{\pi}{2}}[1 \text{ m } C_3(t^2)] - c(t)e^{-t}$ where the "+" is used when t < 0 and the "-" is used otherwise. In the latter expression, C_3 is, curiously, the chi-square CDF with three degrees of freedom.One can easily see that when the truncation point t is small, say on the order of -5 or smaller, E(Z) differs little from 0, the mean of the original population. As t increases, E(Z) increases, and for increasingly large truncation points, E(Z) approaches t from above and V(Z) approaches zero. These observations are in accord with intuition.

> Implications the elimination process has for the officer corps are interesting. First, there is a perception that the survisors may tend to be"conservative," and "non-risk" takers.

Figure 2 shows plots of E(Z) and V(Z) as functions of the truncation point, t, and proportions truncated, ((t). Note the rapid decrease in variance as t increases.

Implications of Elimination for Higher Ranks

The Army uses centralized Army-wide "selection" boards to determine officers qualified for promotion and advanced military schooling. Each selection board determines a performance-based "order of merit" ranking of the officers under its consideration. As an over-simplification, officers under consideration for promotion or advanced schooling that are not selected for the new grades or schools either leave or are separated from the Army. For example, officers being considered for promotion to Colonel (COL, or "O6") have successfully passed five such selection boards. Data on success rates from the boards in recent years (for "primary zone" selec-

(*See* **NON-SELECTION,** *p. 22)*

NON-SELECTION
(continued from p. 21)

tion) are approximately as shown in Table 1. If we consider the population of officers considered by the O6 board, we see it has undergone a sequence of five truncations. The overall effect is truncation such that the fraction (.98 x .98 x .74 x .46 x .60) = 0.20 of the original population is available for consideration by the board.

Table 1. Average primary zone success rates for Army officers in recent years.

Board	Primary zone success rate
O1 to O2	.98
O2 to O3	.98
O3 to O4	.74
CGSC	.46
O4 to O5	.60

(There are losses of officers for reasons other than non-selection, but non-selection, or the threat of non-selection, accounts for most of the decreases in the numbers of officers at the succeeding higher ranks.) If we assume the original population of officers has a single dimension of normally distributed performance, and selection boards eliminate officers not having sufficiently high performance, then a COL selection board is effectively considering a truncated normal population of performance, with truncation point corresponding to the 80^{th} percentile of the original normal population.

For a standard normal distribution, truncation at the 80th percentile would correspond to a truncation point, t, of 0. 84. The variance of such a truncated normal is about 0.2 (see Figure 2). We conclude the variance of the population under consideration by the COL board is only about one-fifth that of the original population. This relatively smaller variance makes it more difficult for the board to discriminate among the officers under consideration. Members of selection boards for the higher ranks are sometimes quoted as saying, "All the officers look about the same," and criticisms of the officer evaluation report system, upon which performance ranks are based, are frequently offered. But, the rapid decrease in variance as t increases goes a long way toward explaining this phenomenon. Even if the officer evaluation report system were perfect, and used optimally, there would inevitably be relatively little difference in performance scores at the higher ranks, due to the effects of truncation.

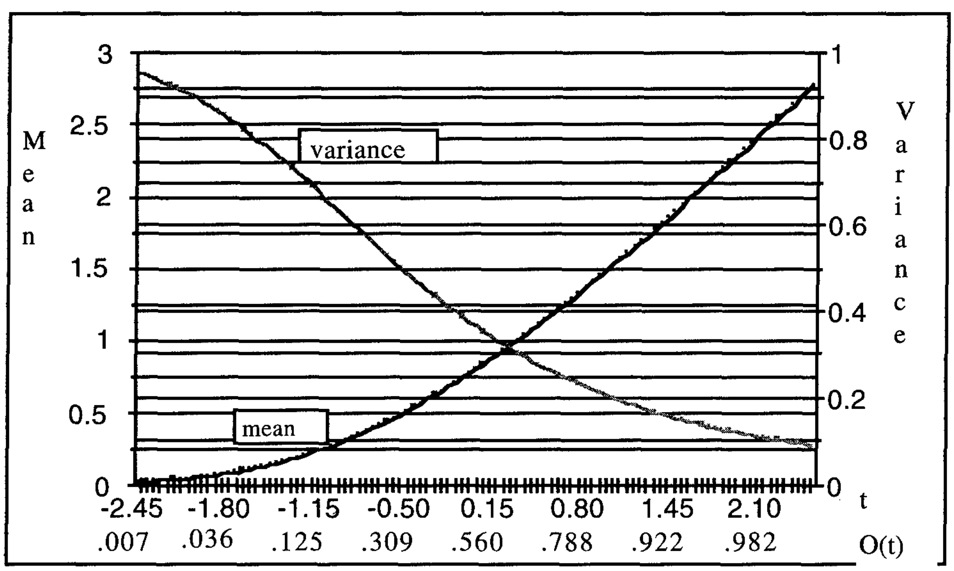


Figure 2. Plot of the mean and variance of a truncated standard normal distribution, as a function of the truncation point, t, and the fraction truncated, ((t).

Members of selection boards for the higher ranks are sometimes quoted as saying, "All the officers look about the same," and criticisms of the officer evaluation report system, upon which performance ranks are based, are frequently offered.

Conclusions

Many so-called "selection" committees are actually operating more like *elimination* processes. This tends to produce a set of surviving members that are middle of the road, with low incentives to be innovative or risk-taking. The compound effects of repeated selection boards leads to survivors that look alike, due to the severe truncation of the original population. This effect will be present, even when a perfect officer evaluation report system is used.

If we are generating an officer corps whose members tend to strictly follow doctrine, we must develop doctrine very carefully. Paradoxically, this must be accomplished in the context of the "revolution in military affairs," in which we encourage bold actions based on rapidly developing information and more complete situational awareness.

Notes

a. Actually, the process is more complicated, of course. A slightly better approximation might be that the "fast track" officers are selected while the remaining officers are subjected to elimination.

Ackowledgement

I am indebted to the following colleagues, who made many helpful comments and suggestions: LTC **Gary Krahn**; LTC **William Carlton**; and LTC **Mike McGinnis**.

Of course, they are in no way responsible for the contents. ✪

The 1998 Army Technology Seminar Game

Dr. **Bruce W. Fowler**
US Army Aviation and Missile Command

This is a report on the 1998 Army Technology Seminar Game held 27-31 July at the Center for Strategic Leadership (Collins Hall) of the Army War College at Carlisle Barracks, PA. The purpose of the game was to determine what systems concepts, and associated underlying technologies, are needed to support Army After Next (AAN) objectives.

The 1998 Army Technology Seminar Game (which is also the first such game) is the brainchild of LTG **Paul Kern**, the Military Deputy to the Assistant Secretary of the Army for Research, Development, and Acquisition, and is managed by Dr. **Herbert K. Fallin**, the Director of Assessment and Evaluation in the office of the assistant secretary. The Strategic Assessment Center of SAIC provided execution support under Dr. **James Blackwell**. The Game Director was Mr. **Mike Lancaster** of SAIC.

The site host was MG **Robert Scales**, the Commandant of the US Army War College, whose previous assignment as TRADOC Deputy Chief of Staff for Doctrine helped lead the early development of the Army After Next project. Collins Hall is a magnificent war gaming facility built since I was a student at the war college (Class of '91.) It is an impressive building of almost 2 x 10^5 ft^2 and some large number of networked computers. The Center for Strategic Leadership does triple duty of conducting training and investigation war games and hosting senior leadership meetings.

We tend to think of war games as simulations with human beings as decision making components. This game was a bit different (emphasis on seminar here) in that the humans engaged in the game were not coupled directly to a simulation. A more descriptive term might be "team dynamic enabled analytical exercise" but that's a really clumsy name so seminar game is easier and convenient. In this sense, the players were not the usual mix of tacticians, strategists and grand strategists supported by tactical advisors.

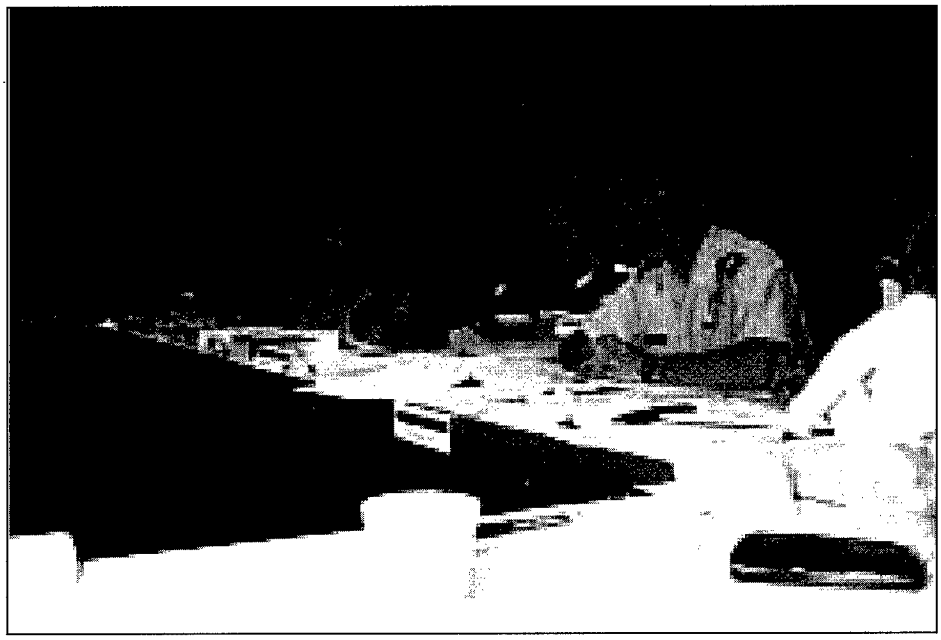


Figure 1. Gaming in a Seminar Group

To describe the structure of the game, we first need to consider the nature of the AAN project. This project, chartered by the Chief of Staff of the Army, GEN **Dennis Reimer**, has the ambitious purpose of elaborating the structure and form of the Army in 2025. The AAN Task Force, located at TRADOC Headquarters, Ft. Monroe, VA, has been developing a working framework of the organization, equipment, tactics and doctrine of that future Army. This work has been ongoing for about two years and has been supported by, among other analytical efforts, periodic strategic and tactical war games.

This in-process product has reached a level of maturity that the time had come to initiate more elaborate and definitive analyses of the AAN equipment (systems) and the technologies that enable those systems by the technical and analytical communities at large. This game was particularly concerned with the Army's and DoD's current and near term technology bases (largely represented by the Army's Science and Technology Objectives (STOs) and DoD's Defense Technology Objectives (DTOs)) and the commercial technology base.

As a whole, the Army Technology Seminar Game consists of five parts, two of which were conducted at Carlisle. The first part consisted of the preparation for the rest of the game. The biggest and most important product of this effort was a database that cross correlated the vignettes and results of the Spring AAN War Game (a classical "combat" simulation war game at a combination strategic-operational-tactical level) the materiel and information systems comprising the AAN force, especially the new AAN Battle Force and its subordinate units, and the Army, DoD and commercial technology base components that potentially enable the systems. This database was constructed by SAIC's Strategic Assessment Center with several preliminary reviews including a workshop sponsored by the Association of the United States Army, led by GEN (Ret) **Gordon Sullivan** and GEN (Ret) **Louis Wagner**, and attended by senior military technologists from both Army and industry laboratories and centers.

The second part of the game consisted of six gaming sessions for each of four

(See **SEMINAR GAME**, *p. 24)*

SEMINAR GAME
(continued from p. 23)

multidisciplinary seminar teams (seminar in this case refers to the conduct of operation in the teams). The teams were comprised of scientists, military and commercial technologists, warfighters and threat experts. Each team evaluated the systems closely associated with six vignettes (approximately 10 systems per vignette) by reviewing the system associated technologies for relevancy and maturity, adding or subtracting technologies, and in some cases, defining new candidate systems. Two of the seminar teams were enjoined to be technically conservative in their review while the other two teams were to consider higher risk technologies. Thus each of the total of twelve vignettes was reviewed twice. The reviews had two component aspects: one a consensual team review assessment (with majority and minority sub-aspects as necessary,) and assessments by each of the individuals comprising the team. These assessments were added to the database in both quantitative (scale) and commentary format.

The third part of the game consisted of a "Hot Wash," a first cut review of the major team findings by a Senior Review Group chaired by Dr. **William Perry** and comprised of senior "grey beards" including Drs. **Paul Kaminski**, and **Joe Braddock**, **Larry Lynn** and **Paul Decker**, GEN **Paul Gorman**, and LTG **John Abrams**, among others.

These two parts of the game were conducted at Carlisle during the week of 27-31 July 1998. The fourth and fifth parts of the game will consist of detailed analyses of the data base developed during the first through third parts of the game. The fourth part, to be performed by SAIC, will consist of a technology oriented statistical and outlier analysis of the data base. (The outlier analysis is intended to specifically address potential technological, organizational, or military "gotchas.") The fifth part, to be performed by RAND, will be a system-of-systems oriented analysis of the database.

For the analytical and decision support community, the 1998 Army Technology Seminar Game signals a change in the scope and optempo of efforts, the first in a series of efforts for the future. With the relative maturity of AAN, consideration of its structure now naturally extends beyond the AAN task force to increasingly include not only the research, development, and acquisition, logistics, training and manning organizations of the Army but of the other services as well. The latter follow from the implicitly and inherently joint form of AAN operations; the former follows from the need to support this future Army with materiel, training, doctrine and sustainment. Further analyses will build on this initial effort to support this development. The results of these analyses will be used to plan and implement the research, development and acquisition of future systems for the Army.

The 1998 Technology Seminar Game presents the analytical community with considerable opportunities. Determining what systems will equip the future Army is more than business as usual.

The nature of these analyses seem likely to be more joint and combined than past analyses because of the tight coupling not only among Army processes, but with other service processes as well. In the past, deployment and sustainment analyses have often been decoupled from combat analyses, and combat analyses have decoupled force structure and material assessments.

The 1998 Technology Seminar Game presents the analytical community with considerable opportunities. Determining what systems will equip the future Army is more than business as usual. It will require more comprehensive analyses of these systems and their enabling technologies and closer interaction between the engineering and operational analysis communities in their analysis efforts.

Author Biography

Dr. ***Bruce Fowler*** *is Technical Director and Deputy of the Advanced Systems Concepts Office, Missile Research, Development and Engineering Center, US Army Aviation and Missile Command and president of the Military Applications Society.* ✪

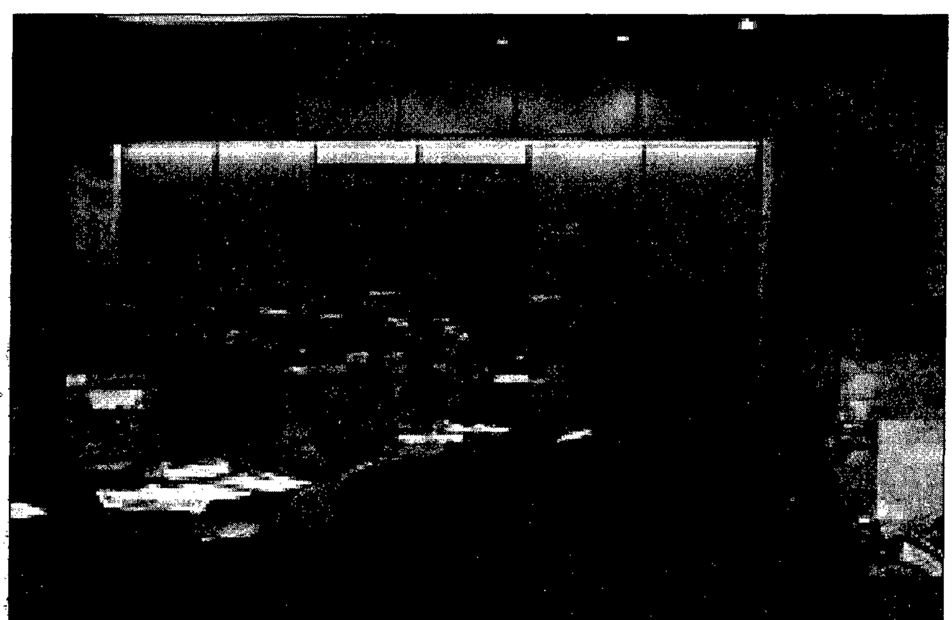


Figure 2. Dr. Perry speaks at the "Hot Wash"

1998 Vance R. Wanner Memorial Award Presented to General Larry D. Welch

Citation

Military operations research contributes effectively to the nation's security to the degree that it meets the evolving needs of defense and conforms to the highest standards of scientific quality and timeliness. To grant recognition to individual practitioners who have made outstanding contributions to the progress of this advancing profession, The Military Operations Research Society has established the Vance R. Wanner Memorial Award. The Directors of the MORS have selected, for this award in 1998:

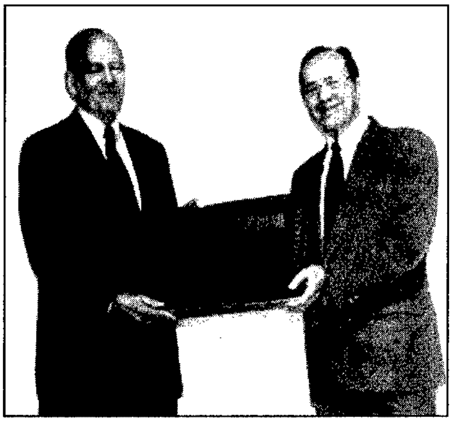
Larry D. Welch

Who has applied a rare combination of vision, leadership and analytical expertise to our most urgent and persistent national security problems. The principles of military analysis and the associated ethics has been an integral part of his leadership roles at the highest level of each of the organizations he has served.

His career in the Air Force started in 1953 and culminated in 1986 when he became Chief of Staff of the Air Force. It continues with his visionary leadership of the Institute for Defense Analyses, together with his broad-ranging contributions to the national security community overall. In the late 1960's he developed the Air Force's first air-to-air combat model and used it to help define the F-15 program. His support of the Military Operations Research Society includes articles of effective analysis and presenting the keynote at a Symposium.

His understanding of military operations has led others to seek his counsel, as is evidenced by his leadership and membership on numerous appointed national-level advisory boards and commissions.

His interests and influence have extended to the highest levels of our government, always marked by an objective and analytically sound basis. For his entire multifaceted career he has been a significant force in advising and shaping the national security agenda, both from a military and a civilian perspective.



Dr. William Perry presents General Larry Welch (Ret) with the Vance R. Wanner Memorial Award.

General Welch's dedication to country, visionary leadership, personal integrity and dedication to quality analysis exemplifies the spirit and ideals of the Vance R. Wanner Memorial Award.

General Welch's Acceptance Remarks

Thank you. I deeply appreciate the honor and thank you without reservation. Still, I feel I have to tell you that there is a certain irony associated with this occasion. When I finished a combat tour while in the Air Force in Vietnam and received orders from the Air Force Personnel System that I was to report to the Assistant Chief of Staff for Studies and Analyses, I regarded that decision as a confirmation of what a lot of fighter pilots have always suspected — that the Air Force Personnel System was served by a decision-aid that consisted of a dart board and darts provided by the lowest bidder. It was beyond the bounds of my imagination that I could belong to anything called studies and analyses. My first meeting with General **Glenn Kent** verified that judgment. The irony, of course, is that I spent five years in this three-year assign-

(See **WELCH,** *p. 26)*

March 1998 Tisdale Award Recipient

OPTIMIZING THE SELECTION OF TOMAHAWK CRUISE MISSILES
Scott D. Kuykendall-Lieutenant, United States Navy
B.S., United States Naval Academy, 1992
Master of Science in Operations Research-March, 1998
Advisor **Richard E. Rosenthal**, Department of Operations Research

The Tomahawk Land Attack Cruise Missile (TLAM), launched from surface ships and submarines, has become the weapon of choice for the United States in many situations. In an era of high precision, fast delivery weapons, the method currently used for assigning TLAM engagements is out of step with the development of the weapons themselves. The missile assignment process used today is essentially manual, with the potential consequences of inefficient missile-to-mission matching the critical loss of time.

This thesis develops a new optimizing approach to missile-to-mission matching, using integer programming. In a matter of seconds for a single ship or a matter of minutes for a battle group, the optimization model determines which missile to select for each tasking order and provides back-up assignments if requested. The objective of the model is to ensure the best weapon is applied against each target while maximizing the potential of the firing unit(s) to perform future taskings.

The new missile-to-mission matching model has proven to perform robustly in extensive sensitivity analysis and is currently being considered for shipboard implementation by the Naval Surface Warfare Center.

KEYWORDS: Tomahawk Land Attack Cruise Missiles (TLAM), Vertical Launch System (VLS), Missile Selection, Missile-to-Mission Matching (M3)

(See **TISDALE,** *p. 27)*

WELCH
(continued from p. 25)

ment and I now regard it as among the most important and productive of my professional life. In subsequent assignments I never escaped from the world of Systems Analysis and Operations Research, nor did I ever try to do so. Among the many labels that have been attached to me over the years, some of which I can't relay in polite company, one that I value greatly is "Defense Analyst."

At the time that I joined the Fighter Division of Air Force Studies and Analyses, we were entering a new era with the lessons of Vietnam, the emerging technologies, many of which Dr. **Perry** mentioned, and the cost and potential effectiveness of new capabilities that were on the horizon. These led to a new set of demands on the world of operations research that I think was unprecedented, at least certainly unprecedented since the end of World War II. And I suggest to everyone here that the contributions the world of military operations research made to the decision processes were very strongly reflected in the performance and the capabilities of the forces that we saw in Desert Storm.

We are now in an era where there is even a greater demand for objective analysis that will help us understand the implications of new technologies and truly revolutionary new capabilities, to include the information technologies that, again, Dr. Perry explained so well. These demands make the analysis needs of earlier periods pale in comparison. I know of no time when defense decision makers have been faced with a more difficult set of choices, and a budget that requires these choices. The capabilities that are reflected in the systems they must choose have the potential for enormous impact on national security and on the capabilities of our national defense apparatus. This adds up to an unprecedented need for objective, innovative, disciplined analysis to help make the decisions that will convert Joint Vision 2010 into Joint Capability 2010 and beyond. It is that challenge that keeps me in Defense Analysis long after I expected to have left the business. It keeps me in the business and it gives me a very special appreciation for any association with an organization that dedicates itself to providing the kind of decision support that helps ensure national security for ourselves, our children and our grandchildren.

I thank you for this award and, more importantly, I thank you for your part in our national security. ✪

MAS Award to MIDN Detar

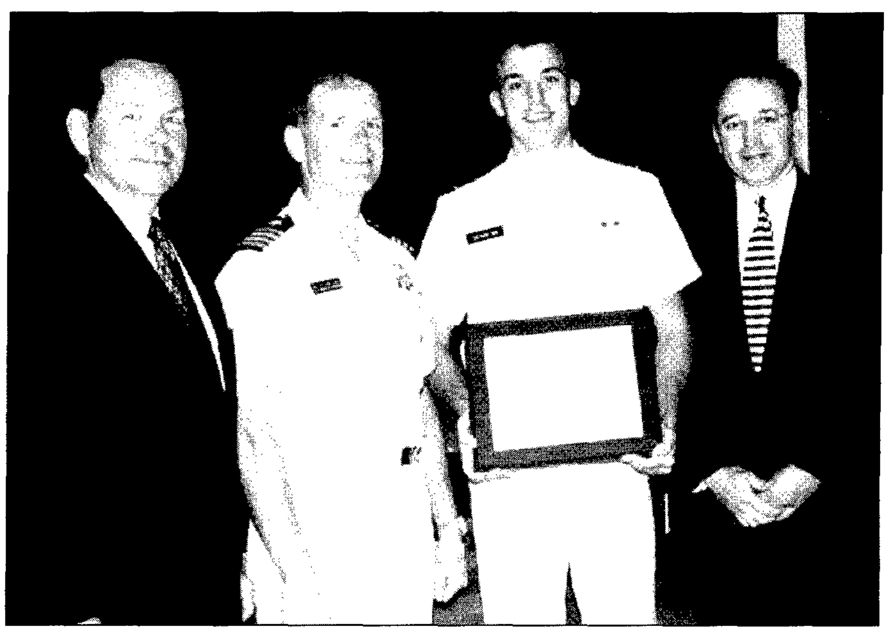
Midshipman First Class **Paul J. Detar** received the 1998 award sponsored by the Military Application Society (MAS) as the Naval Academy's outstanding midshipman in operations research. The award certificate and a check for $300 were presented to Midshipman Detar in a ceremony during graduation week on 19 May 1998 at the Naval Academy.

The award was presented by Dr. **Thomas Frazier** of the Institute for Defense Analyses, on behalf of MAS. As the basis for this award, Dr. Frazier cited Midshipman Detar's outstanding record in operations analysis courses capped by an excellent senior project. His project was entitled "Save Money for the Midshipmen Wardroom Mess by Forecasting." His advisor was Associate Professor **Gary Fowler**.

In addition to his MAS award, Midshipman Detar was given the Military Order of Foreign Wars Prize for the mathematics major achieving the highest grade point average in mathematic courses.

Midshipman Detar graduated on 22 May with a major in Mathematics and was commissioned a Second Lieutenant in the US Marine Corps. He has been awarded a Burke Scholarship and will be allowed to pursue a Masters Degree after completing his first operational tour. He is considering the Operations Research program at the Naval Postgraduate School.

Midshipman Detar comes from Greensburg PA.



(From left to right) Dr. William Miller, Provost and Academic Dean; Captain Howard J. Halliday, Director of the Division of Mathematics and Science; Midshipman Paul J. Detar; Dr. Thomas Frazier of The Institute for Defense Analyses representing the Military Applications Society.

A New Name ... A New Home

E. B. Vandiver III
Director, Center for Army Analysis

On 1 October 1998 the US Army Concepts Analysis Agency (CAA) became the Center for Army Analysis. Still CAA, but with a new meaning. On 25 March 1999 the new CAA will move to a new home in a newly constructed building at Fort Belvoir, Virginia.

Two years ago the Headquarters Redesign Study Group made changes to the size, functions, and organization of the Headquarters of the Department of the Army to realign it with the downsizing that had already occurred in the field. For CAA this entailed assuming the logistics analysis functions of the former Logistics Evaluation Agency, a slight adjustment in manpower and the change of name to the Center for Army Analysis.

The Base Realignment and Closure Commission of 1995 found that it would be economical to move CAA from commercial leased space in Bethesda, Maryland to either renovated or new construction at Fort Belvoir, Virginia. Since all existing structures capable of renovation had already been designated for other organizations, new construction was undertaken. Ground was broken on 3 November 1997 with building completion by the end of 1998. After a period of fit up of communications and furnishings, occupancy is set for the planning date of 25 March 1999. The accompanying photograph shows the new home of CAA as it appeared on 3 October 1998.

The new CAA building will be named Wilbur B. Payne Hall memorializing the late Dr. **Wilbur B. Payne**, first Deputy Under Secretary of the Army (Operations Research) and first Director of the TRADOC Systems Analysis Agency (TRASANA). Payne Hall will be dedicated on 21 May 1999 with the Payne family in attendance. The dedication ceremony will include the unveiling of an artist's portrait of Dr. Payne that has been graciously commissioned by the TRADOC Analysis Center, today's successor organization to TRASANA.

In little over a one year period CAA will have celebrated its Silver Anniversary as the US Army Concepts Analysis Agency; changed its name to the Center for Army Analysis; moved to a new home in a new building; and memorialized Dr. Wilbur Payne, one of the giants of our profession. ✪

The new CAA building.

TISDALE
(continued from p. 25)

DOD KEY TECHNOLOGY AREA: Computing and Software, Conventional Weapons

Biography

Lieutenant ***Scott D. Kuykendall*** *graduated from South Carroll High School in Sykesville, Maryland in 1988. He was accepted as an early applicant to the United States Naval Academy and entered the Academy in July 1988. He graduated with a Bachelor of Science degree in Oceanography, and was commissioned as an Ensign in the United States Navy on 27 May 1992.*

Lieutenant Kuykendall selected Surface Warfare and was assigned for duty on board the USS O'Bannon (DD-987) out of Charleston, South Carolina. En route, he attended Surface Warfare Officer School Division Officer Course, Legal officer School, Damage Control Assistant School and Tomahawk Weapons Officer School. While on board the O'Bannon he was assigned duties as Damage Control Assistant for 24 months and Strike Warfare Officer for 12 months. He did one deployment to the Persian Gulf and one Counter-drug Operation in the Caribbean and Eastern Pacific Ocean.

Following his duties on board the O'Bannon, he reported to the Naval Postgraduate School in February 1996.

His next duty assignment is at SWOSCOLCOM, Newport, Rhode Island, and subsequently as Combat Systems Officer on board the USS Spruance.

He is married to the former ***Melissa Lowe*** *of Mt. Airy, Maryland and has two children.*✪

ACQUISITION
(continued from p. 1)

current? The configuration control and maintenance of the models and simulations are critical: to validate input to virtual environments, to interface with different threats, to interact with other weapon systems and to modernize the weapon system. For example, if a piece of kit is fielded and a training simulation developed that is based on the currently fielded system, what happens if the piece is modernized by spare parts? As we build new systems, or modernize by spares, it will become more critical to build hooks into the weapon system that will enable us to stimulate the sensors or hook into physics models as in a virtual proving ground.

Another area of concern is to what extent logisticians can capitalize on the simulations by using them to discover what might break. Historically, reliability engineers have predicted system reliability using statistical distributions of the historical failure rates. Through the use of physics based modeling techniques, we can now better analyze the failure mechanisms and complex root cause failure modes associated with our systems in the operational environment. One of the advantages of a "Physics of Failure" approach to reliability prediction is that it can be applied earlier in the design process to analyze failure frequency, cost of failure or criticality of failure and to optimize the design for reliability performance.

To accomplish this, we need to evolve physics based, stress related failure prediction models that can be used to identify failure prone components and redesign them to optimize reliability characteristics, enabling increases in reliability growth during the development phases. Better understanding the mechanics of failure will allow closer prediction of when a failure is likely to occur. Knowing this, the logistics community benefits by better spare part prediction and performing proactive maintenance to replace bad components before they fail, avoiding much costlier catastrophic failures.

Some of the other challenges that computer scientists can explore are providing high fidelity, real world simulations: total ownership cost modeling; manufacturing; logistics; developing realistic training simulations (including fog of war) in virtual environments; developing dual use simulations for both acquisition and training; and, continued development of representations of an entity as an object or as a set of performance tables in WARSIM, an Army warfighting simulation.

A benefit of computer simulation not yet actively pursued is harnessing the latest processing capability on board weapon systems for training, repair diagnostics, condition monitoring, etc. The automobile industry is utilizing this capability by utilizing on board diagnostics when we take our car in for servicing.

Transition to the Future. There are many efforts in the Defense analysis community that will impact the manner in which we will do business in the future.

Conducting acquisition digitally implies access to work in progress across the functional areas in the weapon system; training, requirements, logistics, testing, as well as access to the smart product models and integrated environments. This raises issues of proprietary information, configuration control, M&S ownership, access, simulation licensing and maintenance of the models.

The operations research analyst must stay involved in each of the acquisition functions; more robust use of simulations will continue to demand more analysis in support of the weapon system program. We in the analysis community must also grapple with the impact that some of the super models will have on analysis; JWARS, JSIMS and WARSIM. Business in the future will be based on DoD integration of M&S into all functional areas of analysis, and the creation of a seamless interface between DoD and Industry. Acquisition reform is guiding each Service as it moves forward, tearing down the barriers between commercial Industry's successes and the way we used to procure platforms for the warfighters. The technology of the future demands that the Army and DoD change the way they do business to maximize benefits and stay abreast of the best practices available. The analysis community, as the catalyst to make M&S an effective tool, must find or create the tools which will support this dramatic change.

The tools that best serve the analysis community need to foster interoperability and reusability so that the benefit is maximized to all Services and functional areas. The creation of some standards will be necessary in order for everyone, DoD and Industry alike, to communicate and "level the playing field." The Army is aggressively pursuing standards in all areas of M&S. Likewise, the Joint community is concentrating model development on tools that will ensure standards and interoperability. These models include JSIMS, JWARS, and WARSIM. JSIMS will provide a readily available, valid, synthetic training environment for CINCs, their components and joint organizations to assess warfighting situations and define operational requirements. The Army's Warfighter's Simulation 2000 (WARSIM) is the flagship training simulation to be used as ground forces representation in JSIMS. JWARS will provide a fully integrated, state of the art, joint warfare model for CINCs which will represent unique joint functions, processes and component warfare operations, and will aid in force structure and courses of action analysis. These two joint programs are investigating a Conceptual Models of the Mission Space (CMMS), which sets the stage for a standard that further integrates training and analysis, while maximizing effectiveness and efficiency. Tools and standards which allow seamless communication and integration between Services, and between DoD and Industry, will promote a smooth transition to SBA and avoid many of the pitfalls.

Charge to the Community. What can the analysis community do to assist the transition to Simulation Based Acquisition? Continue to provide and pursue realistic ideas on how to maintain weapon system simulations under configuration control. Our analysts can also monitor development of physics of failure methodology which can then be coupled with intelligent systems and prognostics to accurately predict the useful operating life of components on a fielded system.

You also have the opportunity to make a difference by participating in the development of some of the standards for models used in the Army. Standardizing the Army's Model and Simulation (M&S) processes is a vital step toward achieving the economies, efficiencies and technological potential M&S represents. The Army Model and Simulation Office (AMSO) leads standards groups consisting of Industry, Government and Academia who can submit ideas for standards. To further this

process, AMSO has developed the Standards Nomination and Approval Process (SNAP), a web-based tool designed to track, promote discussion, and vote on draft M&S standards. After a standard has been approved, it is placed in the Army Standards Repository System (ASTARS). Both of these systems are available through the Army node of the Model and Simulation Resource Repository and the AMSO Home Page and I encourage you to become involved in these processes.

There exists today a need for better tools and more robust databases to support weapon system technologies. However well we develop these simulation tools in support of Simulation Based Acquisition, there remains a need for rigorous analysis of the results of the simulations...and well trained operations research personnel to execute these analyses.

Biography

*Mr. **Walter W. Hollis** graduated in 1949 from Northeastern University in Boston, Massachusetts, with a Bachelor of Science degree. Following graduation Mr. Hollis taught in the Physics Department at Northeastern and engaged in graduate study at Boston University. In 1951 Mr. Hollis entered the Civil Service as an Optical Engineer at Frankford Arsenal, PA where he held progressively more responsible positions for 17 years. In 1968 Mr. Hollis, then Chief, Combat Vehicle and General Instruments Fire Control Laboratory, became Scientific Advisor to the Commanding General, US Army Combat Developments Experimentation Command, Fort Ord, CA, a position he held until 1972 when he became a student at the National War College (NWC). In 1973, after graduation from NWC and receiving a Master of Science in International Affairs from George Washington University, Mr. Hollis assumed his position as Scientific Advisor to the Commanding General, US Army Operational Test and Evaluation Agency, Falls Church, VA. He assumed his present post of Deputy Under Secretary of the Army (Operations Research) in December 1980.*

Among the many awards that Mr. Hollis has received are three Presidential Meritorious Executive Awards, one Presidential Distinguished Executive award, and three Department of the Army Exceptional Civilian Service Awards. ✪

AFORS 1998 Sets Attendance Record

Dr. **Roy Rice**
Teledyne Brown Engineering

The Air Force held its Fifth Annual Air Force Operations Research Symposium (AFORS '98) at the United States Air Force Academy, October 1st and 2nd, 1998. The symposium featured professional exhanges, briefings on military and civilian career management, panel discussions and updates on current AF policies on analysis, modeling and simulation. This was the most attended AFORS (over 130 attendees) to date and was sponsored by the Space and Missile Systems Center (SMC).

Specific briefings to the entire group included presentations on

- Global Engagement Operations (GEO)
- Expeditionary Air Force (EAF)
- AF Standard Analysis Toolkit
- JWARS: An Air Force Perspective

Breakout sessions were held where over 25 classified and unclassified briefings were presented by individuals representing seven organizations.

A panel discussion with Q&A on "The State of AF Analysis" was led by Col **Kurt Cichowski** (AFSAA), Mr. **Dave Merrill** (AMC), Col **Jerry Levesque** (ACC), Col **Richard "Hoot" Gibson** (ESC), Col **Dan Litwhiler** (USAFA/DFMS), Lt Col **John Miller** (AFIT/ENS), and Lt Col **Jerry Diaz** (OAS).

The Keynote Speaker for the AFORS '98 was Dr. **David Finkleman**, Director of Studies and Analysis and Senior Scientist, North American Aerospace Defense Command and U.S. Space Command. His address on the history of modeling space assets was highlighted by his personal advice and guidance on conducting OR analysis in general.

At the Awards Banquet, Dr. **Jackie Henningsen**, FS, Associate Director for Modeling, Simulation, and Analysis, Directorate for Command and Control, Deputy Chief of Staff for Air and Space Operations, HQ USAF, delivered an address on Analysis Lessons Learned from the QDR. Dr. Henningsen tasked the Air Force analysis community to start getting ready now for the next QDR.

At the AFORS '98 Awards Banquet, Col **Kurt Cichowski**, Commander of AFSAA, awarded four Analyst of the Year awards. They were awarded to the Company Grade and Field Grade Military Analysts of the Year and the Junior and Senior Civilian Analysts of the Year.

The Junior Civilian Analyst of the Year was Mrs. **Nancy L. Evans**, Air Combat Command, Studies and Analyses Squadron. The Company Grade Military Analyst of the Year was Capt **Dave Lyle**, Office of Aerospace Studies. The Senior Civilian Analyst of the Year was Mr. **Patrick J. McKenna**, USSTRATCOM/J5B. The Field Grade Analyst of the Year was Maj **Mark A. Gallagher**, USSTRATCOM/J5B.

Also, AFORS awarded two Lifetime Achievement Awards. One award went to Dr. **Tom Allen** (Col (ret.)), who recently retired as the Commander of AFSAA. The other award went to Mr. **Clayton J. Thomas**, FS, Chief Scientist of AFSAA, for over 56 years of dedicated service in Operations Research. ✪

VEEPS PEEP
(continued from p. 5)

ing process.

We have a wealth of experience in addressing problems and we need to help decision makers understand we are limited only by the decision makers willingness to include us in the process. By breaking down this barrier and showing our capabilities to address the full range of problems — we will finally begin to achieve the true potential of our profession.

References

1. Scales, John, "Napoleon or Morse & Kimball," *PHALANX*, September, 1998.
2. Ibid., p. 16 ✪

1998 Air Force Operations Research Analyst of the Year Awards

Maj **Harry Newton** (USAF Academy)
Maj **Robert Morris** (Air Force Studies and Analyses Agency)

The Analyst of the Year Awards are given out annually by the Air Force Analytical Community, chaired by Col **Kurt A. Cichowski**, Commander of the Air Force Studies and Analyses Agency. Air Force units are allowed to nominate one analyst in each category. This year a total of 28 analysts were nominated. Selection of the award winners was made by a panel of peers with oversight by AFSAA. The awards were presented at the Analyst of the Year Dinner during AFORS (Air Force Operations Research Symposium) held at USAF Academy, 1-2 October 1998. Over 120 analysts attended the dinner.

Winners of the 1998 Air Force Analysts of the Year Award:

Field Grade: Maj **Mark A. Gallagher** (USSTRATCOM)
Company Grade: Captain **Dave Lyle** (OAS)
Senior Civilian: Mr **Patrick McKenna** (USSTRATCOM/J5B)
Junior Civilian: Mrs **Nancy Evans** (HQ ACC/XP-SAS)

Other nominees were:

Field Grade: Maj **William K. Adams** (HQ ACC/XP-SAS), Maj **Paul S. Copeland** (AFSAA/CC), Maj **David A. Fulk** (AFLMA/CC), Maj **Whitney J. Hulett** (SMC/XR), Lt Col **Lee J. Lehmkuhl** (HQ USAFA/DFMS), Maj **Mark L. MacDonald** (HQ USAF/ XPY), Lt Col **Mark D. Reid** (HQ AFOTEC/CC), Maj **Richard W. Roberts** (OAS)

Company Grade: Capt **Robert M. Block** (USAFA), Capt **James R. Hunter** (SMC/XR), Capt **Brian E. Ralston** (HQ AFOTEC/CC), 2Lt **Michael A. Rosenbaum** (ESC/DIS), 1Lt **Joshua D. Snodgrass** (Det 1, 31 TES), Capt **Thomas J. Timmerman** (AFSAA/CC), Capt **Michael J. Wall** (HQ ACC/XP-SAS)

Senior Civilian: Ms. **Nancy L. Clements** (ASC/XR), Mr. **Stephen R. Ganger** (HQ AFOTEC/CC), Mr. **David M. Hickman** (HQ ACC/XP-SAS), Mr. **Keenen Kloeppel** (OAS), Dr. **James K. Lowe** (HQ USAFA/DFMS), Mrs. **Andree D. Newman** (AFSAA/CC)

Junior Civilian: Mr. **Stephen R. Ganger** (AFOTEC)

Dr. Jacqueline Henningsen, FS (right) and Col Cichowski (left) hosted the Analyst of the Year Dinner held to honor the Nominees for this Award. From left to right Col Cichowski, Mrs. Nancy Evans, Mr. Patrick McKenna, Captain Dave Lyle, Maj Mark Gallagher and Dr. Jacqueline Henningsen, FS.

Please join the Air Force Analytic Community in congratulating the award winners and nominees.

Barchi Prize Paper

An Application of Exploratory Analysis: The Weapons Mix Problem

Arthur Brooks
The RAND Graduate School
Bart Bennett and **Steve Bankes**
RAND

Over the last several years, a new approach to model-based analysis has been developed at RAND. This approach, exploratory analysis, greatly expands on traditional analytic approaches in order to enhance understanding of complex problems, provide a wider range of information for decision makers, improve comparison between alternative models, and thereby enable greater comprehension of policy options. This paper reviews the methodology of exploratory analysis and its advantages over traditional analysis in the context of a search for the preferred weapon mix. We begin by walking through a traditional analytic approach and showing the kinds of results that are often observed. We then perform exploratory analysis, requiring a large number of computational experiments-on the same problem, and show that it provides more information and keener insights than we originally obtained. We continue by describing exploratory analysis more generally, and demonstrate its benefits to the decision maker and the analyst. We also discuss what is required for its routine use.

Rist Prize Paper

The Generation, Use, and Misuse of "PKs" in Vulnerability/Lethality Analyses

Dr. **Paul H. Deitz** and Dr. **Michael W. Starks**
Survivability/Lethality Analysis Directorate
Army Research Laboratory

The Rist Prize Paper will be published in the *Military Operations Research* journal in 1999.

Clayton Thomas, FS and Thomas Allen Receive the 1998 Air Force Operations Research Lifetime Achievement Award

Maj **Harry Newton** (USAF Academy)
Maj **Robert Morris** (Air Force Studies and Analyses Agency)

Mr. **Clayton Thomas**, FS (SES) and Col (Ret) **Thomas Allen** were awarded Lifetime Achievement Awards by Dr. **David Finkleman** (SES-4) for contributions to Military Operations Research at the recent Air Force Operations Research Symposium. The symposium was held at the Air Force Academy and attended by about 150 analysts.

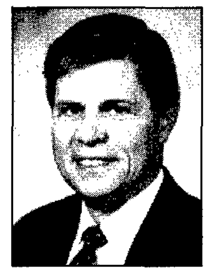
Mr. Thomas was recognized for 56 years of contributions of applying operations research and computer simulation to problems of strategic and tactical importance to the Air Force and the Department of Defense. Starting as a member of the Army Air Corps, Mr. Thomas' contributions span the entire history of the Air Force. In particular, he helped shape the Air Force approach to quantifying military effectiveness and was singularly responsible for bringing a new generation of air and space systems into the Air Force. He has been a mentor for analysts, both inside and outside the Air Force, for a generation. His other awards include: Presidential Rank of Meritorious Senior Executive Service Award, Air Force Exceptional Civilian Service Award, Air Force Meritorious Civilian Service Award, and the Air Force Association Citation of Honor. Clayton Thomas is a Fellow of the American Association for the Advancement of Science and the Military Operations Research Society, which recently established an award in his name to honor individuals for consistent, sustained technical contributions to improve the analytical underpinnings of the military operations research profession..

Colonel (Ret) Thomas Allen, Ph.D., was awarded the AFORS Lifetime Achievement award based on his contributions over 29 years of service, as an analyst and leader. An F-15 pilot and Wing Commander, he helped found the Air Force Analytic Community Steering Group, which sponsors AFORS and is a key reason for the resurgence of analysis in the Air Force. In his last assignment as Commander, Air Force Studies and Analyses Agency, Col Allen oversaw over 200 major studies shaping Air Force weapons systems and force structure, and brought the service into full partnership with the rest of the military in wargaming and distributed simulation. He retired effective 1 July 1998 and is currently a member of the professional research staff of the Institute for Defense Analyses. Dr. Allen was a MORS Barchi Award winner, a National Security Fellow at Harvard University, and the recipient of the Legion of Merit, with one oak leaf cluster, the Meritorious Service Award with three oak leaf clusters and the Air Force Commendation Medal.✪

Clayton Thomas's Lifetime Achievement Award.

Thomas Allen's Lifetime Achievement Award.

Awards and Recognition Update



Dr. **Jerry Kotchka**
Boeing

The Military Operations Research Society exists to enhance the profession of military operations research. Therefore, MORS seeks to recognize excellence in the profession. Annually MORS presents awards and prizes in direct support of the Society's purpose to enhance the quality and effectiveness of military operations research through the recognition of outstanding individuals in the profession and the accomplishment of outstanding work by individuals and teams.

Since 1978, the Vance R. Wanner award has been awarded annually to recognize outstanding individuals for consistent, sustained contributions and dedication to the military operations research profession. It was named in honor of the first Executive Secretary of the Society.

In June 1998, the MORS Board approved two new awards. The first is the Clayton J. Thomas Award to recognize outstanding individuals for consistent, sustained technical contributions to improve the analytical underpinnings of the military operations research profession. It was named after **Clayton J. Thomas**, FS, our respected colleague, who has given, and continues to give, so much of enduring value to the military operations research community.

The second new award is the **John K. Walker**, Jr. Award to recognize the author of the technical article judged to be the best published in *PHALANX* during the previous calendar year. It was named after **Jack Walker**, FS, who was Editor of *PHALANX* for 12 years and Editor Emeritus for seven years.

Since 1965, the Rist Prize has been

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UPDATE
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awarded annually for the best paper submitted in response to a call for papers. It is named after **David Rist**, an early director. Since 1983, the Barchi prize has been awarded annually for the best paper presented at the annual Symposium. It is named in honor of CDR **Richard H. Barchi**, who was a former director. For several years, MORS has awarded the Graduate Research Prize for the best thesis in each operations research class at the Air Force Institute of Technology and the Naval Postgraduate School.

For years, the famous MCAP Award — MORS Coveted Acrylic Paperweight — has been given to keynote speakers, special meeting chairpersons and others who we wanted to thank for their unique participation and support to MORS.

Since 1997, MORS board members and other senior members of the community have been authorized to award "on the spot" the MORS coin for excellence or MORS "Impact Award" for useful and meaningful analysis or other actions that have positive impact on MORS.

Last, but not least, is the very important, instant recognition by supervisors and peers of superb analysis by a "pat on the back" with the words "well done." ✪

MORS PRESIDENT
(continued from p. 3)

Volunteer Society – Tribute to Bosses

MORS relies on its volunteers to conduct the business not handled by our wonderful MORS staff. Not only does this require time and effort from the individual, during and after normal working hours, but also requires the full support of their bosses. I would like to take this "halftime" break to personally thank my boss Dr. **Bill Lese**, FS; who also supports Cy Staniec, mentioned above on the Board of Directors. I would also like to give a standing ovation to the bosses of other Board of Directors members listed below.

Locker Room Pep Talk

The MORS staff and the volunteers of this Society have certainly put together strong first half statistics (no pun intended in an OR crowd). But as everyone knows, it is the score at the end of the ballgame that counts. We must put together a strong second half to be successful. We are also looking at getting our younger players (Junior Analyst) some playing time by participation in the Education Colloquium, other MORS committees and the 67th MORSS. Let's rush out of the locker room and work as a team. Show everyone the MORS Society is an All-Pro outfit!

Board of Directors Member	Boss
Dr. Jerry Kotchka	Mr. Dave Swain, Executive Vice President
Dr. Roy Rice	Mr. John Reece, VP for Defense Programs
Dr. Bob Sheldon	Mr. Wayne Zandbergen, President
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Mr. Ted Smyth	Russell E. Gingras, Director, Joint Warfare Analysis Dept ✪

BIOMEDICAL MODELS
(continued from p. 17)

Summary

The concept of using relatively simple first order models as a building block for more complex models is summarized in Figure 1. As discussed above, modeling all the detailed manifestations of the human system is analytically intractable. This is due to many factors including the large number and interplay of external and internal variables, nonlinearity, time varying nature of responses, nonstationary system properties and effects that are difficult to quantitatively represent. Initial and boundary conditions for dynamic system response functions may also be burdened with related complexities.

Although comprehensive modeling of the human system is a significant analysis challenge, simplification methods can be invoked to manage the complexity to create manageable application-specific models. Conversely, during synthesis, basic response models can be enhanced with additional complexity to enhance their capabilities and scope of application.

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3 McMillan GR, et al. (eds.). "Applications of Human Performance Models to System Design". NYC: Plenum Press, 1989.

4 Cobelli C and Saccomani MP. "Compartmental Models of Physiological Systems" in "The Biomedical Engineering Handbook" [ed.: Bronzino JD]. Boca Raton, FL: CRC Press, 1995.

Author Biography

Dr. ***Matthew Reardon*** *is a principal Investigator with SAIC. He earned a medical degree from the University of South Florida, an MPH from Boston University, and engineering degrees from the University of Florida, University of Central Florida, and Northeastern University. He previously was a research scientist at the Army's Aeromedical and Environmental Medicine research labs. He has numerous publications in biomedical modeling, environmental stress, and aeromedical factors.* ✪

GAMES
(continued from p. 7)

Specification of Four Games

Let the payoff matrix of the game be denoted by:

$$A = a_{ij} \text{ (i=1,...,m and j = 1,...,n).}$$

1. Game 1 (Both Sides Have Correct Information)

In the first game Side 1 and Side 2 have common and correct knowledge of all of the values of the payoff matrix A. Side 1 chooses his maxmin strategy and Side 2 chooses his minmax strategy and the payoff corresponding to this choice results. The payoff of the game is:

$$\text{Payoff of Game 1} = a_{i^*j^*}.$$

Since the underlying payoffs are random and distributed uniformly between 0 and 100 the expected payoff is 50. Any other result of the 1000 trials would indicate that the computer program is incorrect.

2. Game 2 (Side 1 Has Correct Information and Side 2 Has Incorrect Information)

In the second game Side 1 has correct knowledge of all of the values of A (call this matrix A_1) and Side 2 has a completely incorrect payoff matrix A_2 composed of a second set of random numbers between 0 and 100.

Side 1 chooses his maxmin strategy from the correct matrix A_1. Side 2 chooses his minmax strategy j*(Game 2) from the incorrect matrix A_2. The payoff of the game is:

$$\text{Payoff of Game 2} = a_{i^*j^*(\text{Game 2})}.$$

3. Game 3 (Side 1 Has Correct Information, Side 2 Has Correct Information and Side 1 Knows Side 2's Choice)

In the third game both Side 1 and Side 2 have correct knowledge of the values of A.

Side 2 chooses his minmax strategy j* from the correct matrix A.

Side 1 knows the choice of Side 2. Rather than choose his maxmin strategy he focuses only on the payoffs corresponding to the minmax choice of Side 2 and maximizes his payoff. From the correct matrix A Side 1 chooses:

$$i^*(\text{Game 3}) = i \text{ corresponding to } \underset{i}{\text{maximum}}\ a_{ij^*}.$$

Game 4, with both bad information for Side 2 and Side 1's knowing Side 2's move, yields a marginal gain of 41.2 over the expected payoff of 50.0.

The payoff of the game is:

$$\text{Payoff of Game 3} = a_{i^*(\text{Game 3})j^*}.$$

4. Game 4 (Side 1 Has Correct Information, Side 2 Has Incorrect Information and Side 1 knows Side 2's Choice)

In the fourth game Side 1 has correct knowledge of all of the values of A (call this matrix A_1) and Side 2 has a completely incorrect payoff matrix A_2 composed of a second set of random numbers between 0 and 100.

Side 2 chooses his minmax strategy j*(Game 4) from the incorrect information of A_2.

Side 1 knows the choice of Side 2. Rather than using his maxmin strategy he focuses only on the payoffs corresponding to the minmax choice of Side 2 from the incorrect information. From the correct matrix A_1 Side 1 chooses:

$$i^*(\text{Game 4}) = i \text{ corresponding to } \underset{i}{\text{maximum}}\ a_{ij^*(\text{Game 4})}.$$

The payoff of the game is:

$$\text{Payoff of Game 4} = a_{i^*(\text{Game 4})j^*(\text{Game 4})}.$$

Results

Results are given for three sets of four games. They are as follows:

Number of Strategies per Side	Game 1	Game 2	Game 3	Game 4
3X3	50.0	62.5	57.5	75.2
5X5	50.2	60.8	65.4	83.0
10X10	48.9	58.9	75.4	91.2

These results show that the expected payoff is highly sensitive to the information of both sides.

For Game 1 the expected payoff is always approximately 50, which validates the simulation.

For the 10X10 case the increase in expected payoff from Game 1 to Game 2 to Game 3 to Game 4 is very interesting. Game 2, with Side 2 having bad information, yields a marginal gain of 8.9 over the expected payoff of 50.0. Game 3, with Side 1 knowing Side 2's move (even though Side 2 has good information) yields a marginal gain of 25.4 over the expected payoff of 50.0. Game 4, with both bad information for Side 2 and Side 1's knowing Side 2's move, yields a marginal gain of 41.2 over the expected payoff of 50.0.

For the 3X3 case the effects are quite different than for the 10X10 case. Game 2, where Side 2 has bad information, yields a marginal gain of 12.5 over the expected payoff of 50.0, compared with 8.9 in the 10X10 case. Game 3, where Side 1 knows Side 2's move, yields a marginal gain of 7.5, compared with 25.4 in the 10X10 case. Game 4, where Side 2 has bad information and Side 1 knows Side 2's move, yields a

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marginal gain of 25.2, compared with 41.2 in the 10X10 case.

The overall effects of information are not usually as great in the 3X3 case as in the 10X10 case but there are some exceptions. Bad information for Side 2 has more relative effect in the 3X3 case. Side 1's knowing Side 2's choice has more relative effect in the 10X10 case. Combining the effects of Side 2 having bad information and Side 1 knowing Side 2's choice has a relatively more pronounced outcome in the 3X3 case than in the 10X10 case. That is, in the 3X3 case the increase of 25.2 in Game 4 is much larger than either of the single effects in Game 2 and Game 3, while in the 10X10 case the increase of 41.5 in Game 4 is not that much larger than the single effect in Game 3.

> The insight to be gleaned from this analysis is that non-optional decision rules can lead to significantly inferior resuls compared to optimal game-theoretic solutions.

There is an interesting technical explanation for the relative sensitivity to information of the 3X3 case and the 10X10 case in Game 2. In the 3X3 case there is a fairly high probability that all three of the values for a particular choice of Side 1 will be equal to or greater than 50, namely $.5^3 = .125$. The probability that at least one of the three choices of Side 1 will be equal to or greater than 50 is $1 - .875^3 = .33$ Since Side 2's choice is essentially random due to having bad information, Side 1 will receive either the expected value of 50 or will receive the improved value about one-third of the time.

In the 10X10 case, however, there is a low probability that all of the values for a particular choice of Side 1 will be equal to or greater than 50, namely $.5^{10} = .00097$. So Side 1 can't capitalize on choosing a strategy with a payoff greater than 50 much of the time. Instead Side 1 must settle for the improvements in outcome due solely to the informed choice of Side 1 coupled with the uninformed choice of Side 2.

In Game 3, as compared with Game 2, there is a different set of driving factors. In the 3X3 case Side 2 can guarantee that Side 1 will receive a certain fairly low payoff and, even though Side 1 knows Side 2's strategy, Side 1 cannot significantly exploit this knowledge. In the 10X10 case, however, Side 2 cannot guarantee that Side 1 will receive a fairly low payoff and Side 1 has a wide range of options for taking advantage of the information about Side 2's choice. Thus the outcomes differ greatly between the 3X3 case and 10X10 case in Game 3.

Sensitivity to Decision Rules Versus Game-Theoretic Solutions

Results of four more games are presented here. These games include a myopic decision rule for Side 2 as follows. Side 2 first chooses strategy 1. He then examines strategy 2 to see if it reduces the maximum which Side 2 can lose; if so he adopts strategy 2 and if not he settles finally on strategy 1. If he adopts strategy 2 he then examines strategy 3 to see if it reduces the maximum which Side 2 can lose; if so he adopts strategy 3 and if not he settles finally on strategy 2. This procedure is performed until he settles finally on a strategy.

The above procedure is representative of a non-optimal decision rule rather than a game-theoretic optimal strategy.

A new set of computations is performed for the four original games and the four new games. This time the games are repeated 2000 times with a different random number seed.

Results are as follows for the four original games:

Number of Strategies per Side	Game 1	Game 2	Game 3	Game 4
3X3	50.1	61.2	58.0	74.5
5X5	50.5	60.5	65.3	83.7
10X10	49.7	59.1	75.0	90.8

Results are as follows for the four new games with Side 2 using non-optimal decision rules:

Number of Strategies per Side	Game 1	Game 2	Game 3	Game 4
3X3	51.7	61.9	60.5	74.5
5X5	54.4	60.5	72.8	83.5
10X10	55.6	57.9	85.0	90.7

There are no significant differences in Game 2 and Game 4. This is because Side 2 has incorrect information in these games and so non-optimal decision rules are equivalent to optimal decision rules.

There are significant differences, however, in Game 1 and Game 3. The adoption by Side 2 of a non-optimal decision rule in the 10X10 case increases Side 1's payoff by an increment of almost 6 percent in Game 1 and 10 percent in Game 3.

The insight to be gleaned from this analysis is that non-optimal decision rules can lead to significantly inferior results compared to optimal game-theoretic solutions.

ACKNOWLEDGEMENT

We are grateful to Lowell Bruce Anderson for suggesting the sensitivity analysis of non-optimal decision rules discussed in the "Sensitivity to Decision Rules Versus Game-Theoretic Solutions" section.

REFERENCES

[1] *Joint Vision 2010*, pp. 16.
[2] *Army Vision 2010*, p. 10.

Introduction to *PHALANX* Online

CAPT **Lee Dick**

Lee Dick

This edition of *PHALANX* begins a new horizon, a web supplement, *PHALANX* Online. Two years ago, as Electronic Media Chairman, I vowed to bring the Society into the electronic age, by instituting a MORS web homepage and by leveraging the power of electronic email to stimulate activity and professional discussions. I've now volunteered to assume the role of PHALANX Associate Editor, to bring the Society's premier voice, *PHALANX,* into the 21st century.

First, the web edition will complement, not replace or duplicate, our familiar and well cherished published document. The first online edition provided an overview of the key articles in the upcoming published version. My hope is that it made you as anxious to read the articles as it did for me to write these summaries in an attempt to pique your interest. As we expand the online capability, we will now have a conveyance for administrative articles, and announcements which often times were either omitted or abbreviated because of a lack of space, or they choked out the entree, a technical article. As we continue to grow the online capability, we may even want to publish a technical article in its entirety on the web. It would, of course, compete with the regular published articles as a Walker Award candidate. Any volunteers? We can do multi-media!

The online *PHALANX* will also greatly add to the exchange of professional information, such as feedback or counterpoint articles. This is key in stimulating growth and interest in the Society yet our current method is relegated to a subsequent edition or two of *PHALANX* to generate or comment on another article. This is much too slow. We can leverage on the power of the web to improve that process by at least an order of magnitude. My vision is to bring this online, with the ability to insert short paragraphs in an online discussion area, to either add to or debate a published article.

In closing, I leave you with one thought....I'm sure **Jack Walker** would have endorsed this wholeheartedly as a measure to significantly improve the professional communications within our Society.

May the final year of the millennium bring you much happiness and success! ✪

Simulation Validation (SIMVAL) Workshop '99

Making VV&A Effective AND Affordable
26-28 January 1999, Johns Hopkins University/APL

In the late 1980s, MORS initiated a series of workshops to serve as a forum for dialogue on the issue of simulation validation (SIMVAL). That forum was the genesis of DoD's definitions for Verification, Validation and Accreditation (VV&A), which have become central themes in DoD modeling and simulation. Recent developments in the policies and procedures governing VV&A underscore a new need to advance the state-of-the-art in VV&A technologies and relate those technologies to the needs of DoD organizations. This examination should include not only tools and methodologies for performing V&V, but should also address costs associated with conducting VV&A. In particular, technologies should be identified that can increase V&V effectiveness without increasing costs, or decrease costs without degrading V&V effectiveness.

To address this need the Military Operations Research Society has organized a Workshop to examine the question of "Making VV&A Effective AND Affordable." This Workshop will be held 26-29 January 1999 at the Kossiakoff Conference Center of Johns Hopkins University/ Applied Physics Laboratory, in Laurel, Maryland. If you would like more information about this meeting or would like an application to attend please visit our web site at www.mors.org or call the MORS office at (703) 751-7290. ✪

TESTING
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focused on priority user concerns.

- Test planning and reporting was facilitated because one measure of performance applied to three critical operational issues.
- The validity of the results was enhanced because SMEs from the user community were the best-qualified persons to assess mission tasks.

Summary. Application of this measure of performance requires a significant commitment from the user community. For example, the users provide input to the mission task list and provide the SMEs. The result is a test highly focused on user concerns.

In any system where the requirements are "soft" and there is a lack of quantitative thresholds, this focus on the ability of the system to support user missions facilitates the operational evaluation. The technique of assessing task success based on the goodness of information can be applied to other C4I systems. The characteristics of timeliness, accuracy, completeness and usefulness are appropriate measures for information goodness.

The views expressed in this article are those of the author(s) and do not reflect the official policy or position of the Department of Defense or the US Government.

Biographies

*Lieutenant Commander **Mark Thompson** is the JITC GCCS operational test director. He is a graduate of the US Naval Academy and received his Master of Arts in National Security and Strategic Studies from the Naval War College. He has 13 years experience as a Navy submariner.*

*Dr. **Ernest Montagne** is the Chief Scientist for Systems Test, Evaluation and Analysis at BDM International. He received his Doctor of Science in Operations Research from George Washington University. He has over 30 years professional experience, to include 10 years in OT of major Defense systems. He is a member of ITEA, the Military Operations Research Society (MORS), the Institute for Operations Research and Management Science (INFORMS), and the Armed Forces Communications Electronics Association (AFCEA).* ✪

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THE LAST WORD

PHALANX Online

Julian Palmore

The use of electronic media by MORS has increased and matured over the past several years. It is now time for *PHALANX* to take a step into the electronic Web World. We do so at the suggestion of CAPT **Lee Dick** who has agreed to be Associate Editor of *PHALANX* for *PHALANX* Online. This step is significant. As an electronic supplement *PHALANX* Online will allow *PHALANX* to reach a wider audience more effectively. It will allow larger versions of articles and announcements to appear in full as supplements to that printed in *PHALANX.* With Lee's enthusiasm and extensive knowledge about the use of the web and the conversion of MORS activities to it I'm sure *PHALANX* Online will be a great success.

Please see Lee Dick's article on page 35 for more details. ✪

This Just In ...

Three new Fellows of the Society were elected at the 8 December Board of Director's Meeting. They are, in alphabetical order: Mr. **Brian McEnany**; Dr. **Stu Starr**; and Dr. **Harry Thie**. Elevation to the status of Fellow of the Society is reserved for individuals who have made significant and lasting contributions to the Society. We thank these individuals for their continued service and look forward to many more productive years with MORS. Congratulations!!

Congratulations are also in order for LTC **Michael L. McGinnis**. He has recently been selected as Department head at the United States Military Academy's Department of Systems Engineering. ✪